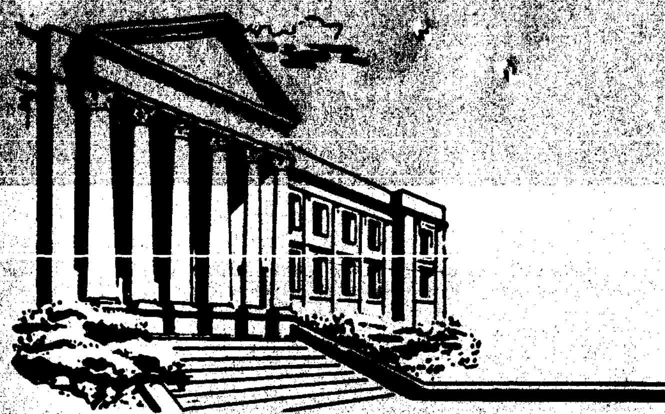

NASA-CR-65077

N65-30635
(ACCESSION NUMBER)
128
(PAGES)
(NASA CR OR TMX OR AD NUMBER)
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(CATEGORY)

FACILITY FORM 602

Final Manual

FM-B2154

OPERATION AND MAINTENANCE MANUAL
FOR THE
FRANKLIN INSTITUTE LABORATORIES UNIVERSAL PULSER
FILUP 2

GPO PRICE $ ________

CFSTI PRICE(S) $ ________

October 1964

Hard copy (HC) 4.00

Microfiche (MF) 1.00

ff 653 July 65

Designed and Developed for

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Manned Spacecraft Center

under

Contract NAS 9-2106

THE FRANKLIN INSTITUTE
LABORATORIES FOR RESEARCH AND DEVELOPMENT
PHILADELPHIA PENNSYLVANIA

THE FRANKLIN INSTITUTE • *Laboratories for Research and Development*

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FOREWORD

The FILUP 2 is designed to be the most useful and versatile equipment for testing electroexplosive devices so far developed. This instrument combines the capabilities of three earlier instruments to provide full input testing for any known electroexplosive device. In addition it can provide an input current of constant slope, which to the best of our knowledge is a new development.

Mario J. Falbo of ESDE has been Project Officer for most of the contract period. He was succeeded by Irvin Wind during the execution of the contract.

Credit for design and construction of the equipment must go to personnel too numerous to mention who have constructed earlier test sets and to those who have tested and evaluated electric initiators for nearly 12 years at the Franklin Institute.

Acknowledgement for the construction of this equipment must include William C. Reisener who designed the ramp generator and to Willard Weiss and Warren Dunning who constructed the equipment and developed much of the circuity.

Charles T. Davey
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1. INTRODUCTION

The need for a universal test set for electroexplosive devices (EEDs) was foreseen by NASA personnel because of the frequent use of electroexplosive devices in space vehicles. The EED can initiate chemical reactions or perform mechanical tasks, which would otherwise require arrangements which are heavier by orders of magnitude.

During the past 15 years an entire technology has been built around the EED. There is a constant need to evaluate the input sensitivity and functioning time of new devices as well as to monitor the quality of the ones long in production. In determining the sensitivity and the performance of EEDs, a number of different transducer mechanisms have been used, usually to achieve a specific sensitivity or electrical imput impedance. Carbon bridges, conductive mix, (both carbon and metal), spark gaps, hot and exploding wires, and a number of new hybrid devices have been developed. Some of these are characterized as being one-ampere, one-watt initiators in reference to a well-known specification for sensitivity. Previously, specific instrumentation was developed for each type of device: one type of device, one test set. Different equipment and standards have been used in evaluating electric initiatiors,to the point where confusion prevails within organizations, as well as between manufacturer and user.

Each circuit and measurement that is used in FILUP 2 has been thoroughly checked. All equipment design, save the slope generator, has been proven in earlier test sets. Modifications have been made to keep the equipment current with latest technology.

The design of FILUP 2 is such as to accommodate the input requirements of all existing electroexplosive devices.

General features include the capability of measuring resistance, outputs having any of several wave forms, and measurement of functioning time. In addition, the equipment has provisions for recording waveforms to determine the rate of resistance change of the EED under excitation from constant current, observation of bridgewire opening time,and in some instances ignition time of the charges in the explosive.

Each generator contained in the equipment is an integral unit that may be easily controlled and rapidly applied to its assigned task. Secondary standards are built into the equipment to end confusion on problems related to EED sensitivity. Switching losses and wave shapes have been thoroughly checked; in most cases similar circuits have already been in use for a few years in other equipment for the same purpose.

Figure P1* is a photograph of the equipment showing all of the units contained in the equipment. At the left is the 160 volt, 50-ampere power supply, in the center is the FILUP instrumentation, at the right is the firing chamber. Each portion of the equipment is labelled and identified.

It is beyond the scope of this manual to discuss the methods of testing electric initiators and the methods of treating data derived from testing. It is important for the user of this equipment to be aware of available test and analysis procedures. Without this information, the equipment will be of little use. The following bibliography is a source of additional information on testing electric initiators and analysis of the results of these tests.

* P-numbers refer to photographs appended.

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2. CIRCUIT PRINCIPLES

The equipment will be discussed in this section in a simplified manner to allow the operator to obtain an understanding of the principles of the equipment. This section will also serve as an introductory guide to maintenance of the equipment. The units will be described in order of probable frequency of use.

2.1 Entire Equipment (P-1)

Figure S-1 is an overall block diagram of the equipment, showing the interconnections and the individual instruments.

2.2 SCR Generator (P-4)

The SCR generator output generator using a silicon controlled rectifier consists of the 160-volt, 50-ampere power supply, the SCR itself, a timing circuit to initiate and terminate conduction of the SCR, and banks of series resistors to provide current stability. The counter indicates pulse application time, using impulses from the timing circuit. Current amplitude is determined by power supply voltage and series resistance. This unit provides rectangular pulses, constant current up to 30 amperes, voltage up to 160 volts at 50 amperes for durations as short as 200 microseconds and up to 10 seconds, or over.

2.3 Ramp Generator (P-4)

Similar to the SCR generator, the ramp generator controls the output of the 160-volt power supply. A transistor-feedback amplifier allows current to increase at a rate predetermined by constants of the amplifier. The slope is variable from a maximum of 20 amperes in 500 microseconds to 500 milliamperes in about 12 seconds. The range of slopes is completely variable from a minimum of 10 ma/sec to the upper limit mentioned above.

In the ramp generator as well as the SCR generator, the SCR is used to start and terminate conduction. The SCR eliminates leakage current that might otherwise be present before and after termination of the current ramp.

2.4 PFN Generator (P-3)

The PFN Generator (output generator with pulse-forming network) consists of a tapped pulse forming network with pulse width variable in steps from 1 microsecond to 100 microseconds. The PFN provides rectangular pulse of current or voltage that are of shorter duration than can be provided by the SCR Generator. The PFN is charged from the 0-3000 volts precision power supply and discharged through a relay to the load consisting of 50-ohm resistor and the device under test. The current range is from zero to 30 amperes, variable by adjustment of the precision power supply.

2.5 Capacitor Discharge Generator (P-5)

Capacitor discharge testing is chiefly used for carbon bridge detonators and for sensitive wire bridge devices.

The generator in FILUP 2 consists of a bank of firing capacitors covering a wide range of capacity plus a location for a spare. The variable 3000-volt power supply is used to charge the selected capacitor, subject to the limitation of 1000 volts maximum for protection of the capacitor.

At the desired instant the firing switch transfers the capacitors from the power supply to the firing line, subjecting the initiator under test to the capacitor discharge.

2.6 Exploding Bridgewire Generator (P-6)

The exploding bridgewire tester is also a capacitor discharge test device, but it is designed for higher voltages and uses capacitors especially designed to have low internal inductance.

The selected capacitor is charged from the 0-3000 volt power supply and discharged by means of ignitron control through the bridgewire and a 0.05-ohm short.

2.7 Measurements (P-7, P-9)

Measuring equipment includes a digital voltmeter, and electronic counter and an oscilloscope. These instruments are used to measure potential and time. To perform these measurements, internal connections are made by switches on the panel.

Resistance is indicated digitally. A digital voltmeter with a calibrated amplifier is used to measure the voltage drop produced by a known current. The current is selected small enough so that the device will be quite unaffected, and of such value that the voltmeter indicates directly the significant figures of the resistance, the decimal point to be located from knowledge of the current and the amplifier characteristics.

Current and voltage magnitude are also observed by means of the digital voltmeter. Pulse times of 10 seconds are set on the SCR generator and the potential is monitored under load. Current is indicated by measuring the potential across a 1-ohm resistor with the digital voltmeter. The voltage reading in this case is numerically identical to the current.

The magnitude of short duration pulses is measured using the plug-in unit provided on the oscilloscope.

Pulse width for SCR generator is monitored using the electronic counter. Special switching is included for this purpose. The counter is also used to measure functioning time.

Special measurements such as determination of ignition time and bridge wire breaktime or dynamic resistance are made using the oscilloscope.

3. OPERATION

Operation of FILUP 2 is as easy as the operator wishes to make it. Standing back and looking at all the switches, controls, lights and meters at one time, one gets the impression that this equipment is complicated; it isn't. Each unit serves a function that has been described briefly and simply in Section 2. Although this information is not adequate for operation of the equipment, it helps in understanding the function of each control and each switch. Operation of the overall equipment and each generator will be discussed in this section. Following this discussion while looking at the accompanying pictures, or better yet, while observing the equipment, will familiarize the operator with the equipment.

Practice runs can easily be made, by using light bulbs in place of initiators. This is inexpensive and safe. Furthermore, the light bulb has some convenient properties that simulate detonator performance. These will be discussed later.

3.1 Operational Characteristics

In operating FILUP 2 and interpreting results, it is important to understand the operating characteristics of the equipment. This is best done by the use of a series of curves that are the results of measurements made on the equipment.

Figure 3-1 shows the current regulation of the SCR generator with the available values of series resistance. This curve illustrates that changes in the initiator resistance affect current. The magnitude of this effect is less for large series resistance. Fortunately, initiators requiring less current (more sensitive) are higher in resistance than the less sensitive ones. It is also true that initiators requiring higher current usually have lower resistance and also less change in resistance. The result is that the characteristics are to some extent self-compensating.

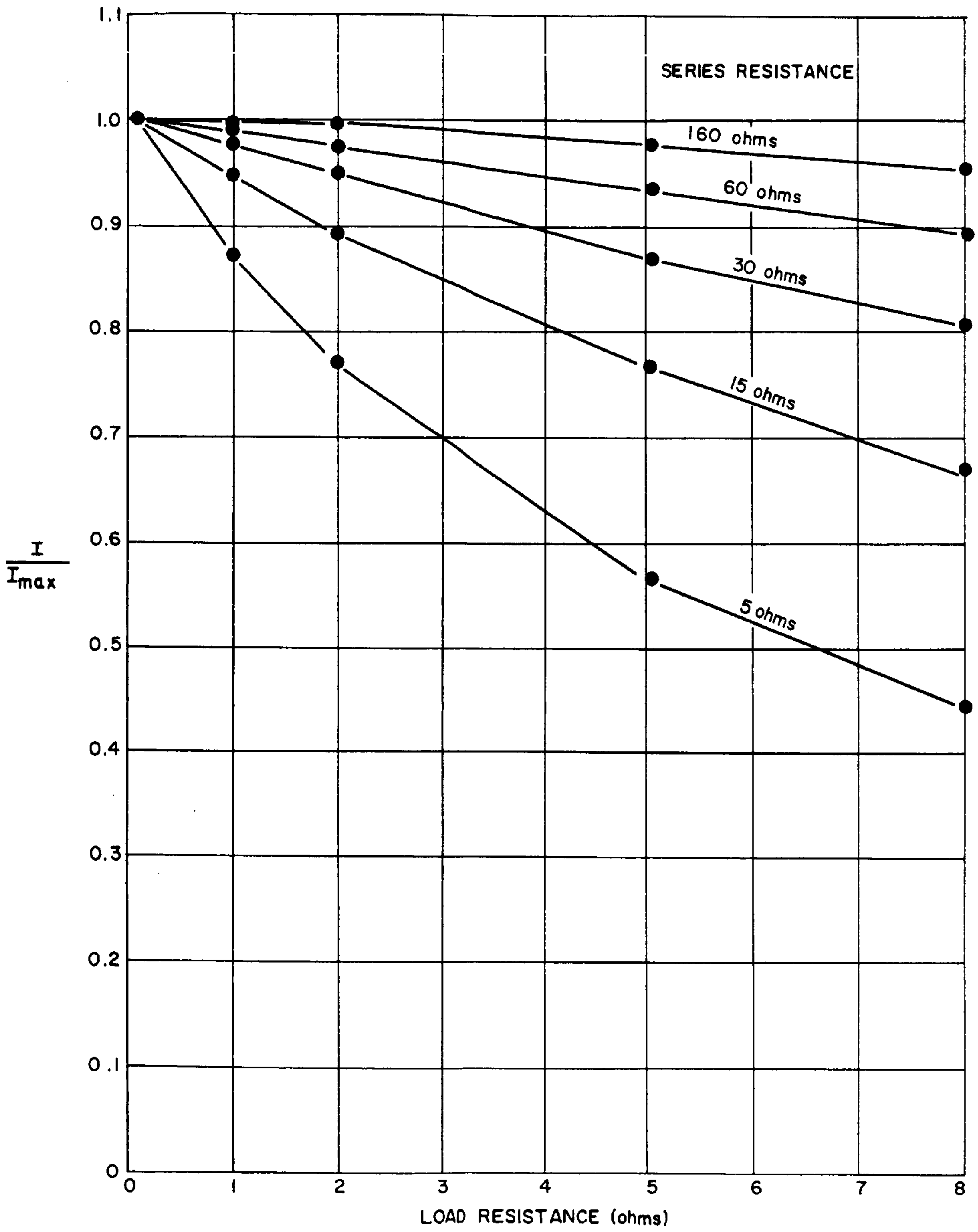


FIG. 3-1. CURRENT REGULATION OF SILICON CONTROLLED RECTIFIER GENERATOR

Constant voltage characteristics of the SCR generator are shown in Figure 3-2. The importance of exposing initiators with relatively large resistance to constant voltage pulses is illustrated here. The importance of using a relatively low value of shunt resistance is also made apparent by these curves.

Similar curves of regulation have been made for other generators. Figure 3-3 shows the voltage regulation of the PFN generator. It is obvious that this generator, when intended to supply constant voltage pulses, should be used only for resistances that are relatively high, say from 500 ohms upward.

It may supply constant current pulses for wire bridge devices with low resistance.

Functioning time measurements are usually highly reliable using the system contained in the equipment. A check of the stop circuit can be readily made, using a commercial #44 pilot lamp. The results of such a test are shown in Figure 3-4. The pilot lamp is placed against the plexiglass shield in the firing chamber and connected to the firing leads. The capacitor discharge generator is set up for use as described in the manual, using a 16-microfarad capacitor. For several different capacitor potentials, the observed functioning time on the counter should be nearly the same as that shown in the figure. This checks both the timing circuit and the capacitor discharge generator.

3.2 Choice of Generator

The choice of the generator will generally be made in advance; if the operator must make the choice, it is not usually a difficult one. Some knowledge of the device under test will be available. For example, it will have a hot-wire bridge, carbon bridge, conductive mix or an exploding wire. The approximate functioning level will be known, either from manufacturer's data or from design information.

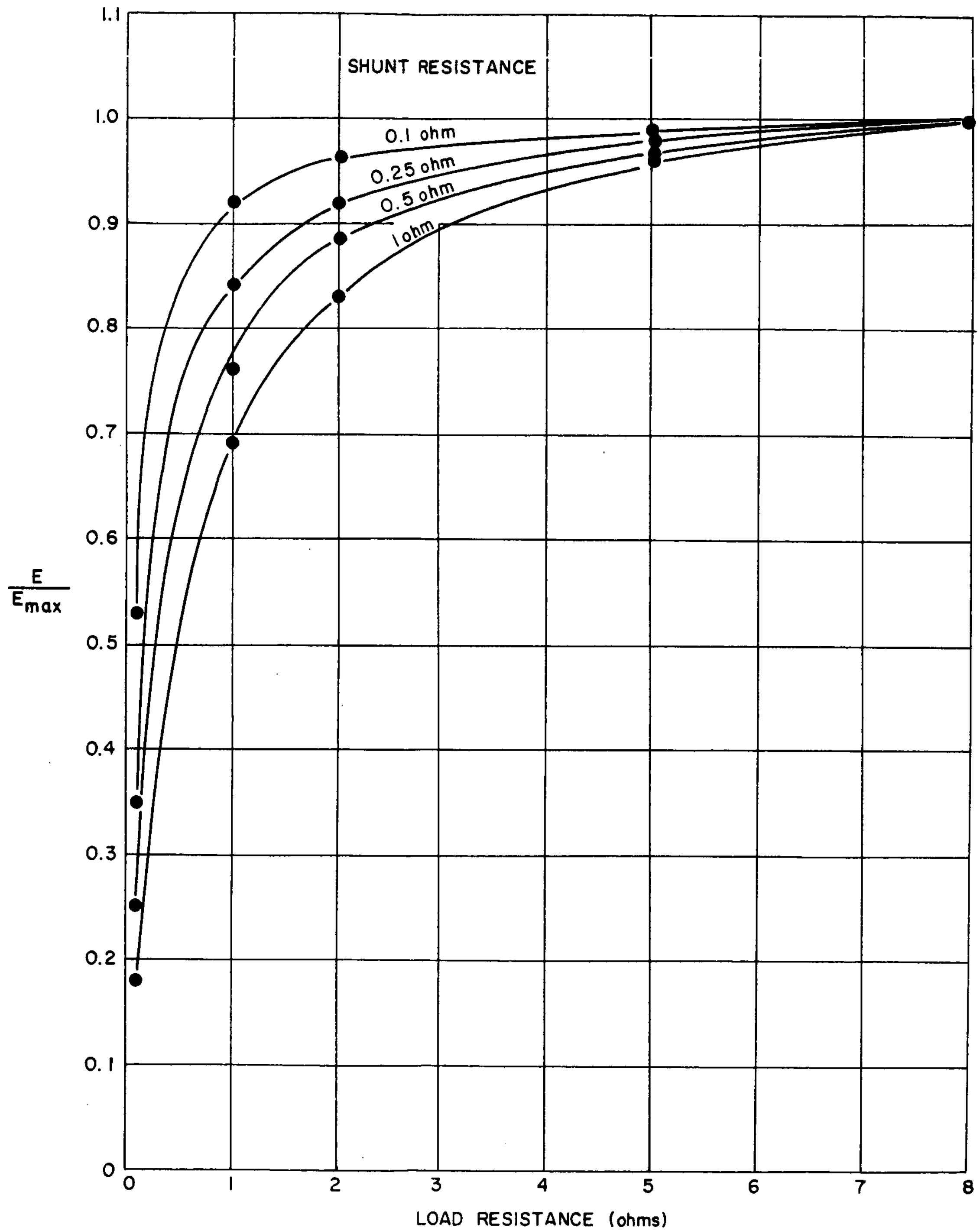


FIG. 3-2. VOLTAGE REGULATION OF SILICON CONTROLLED RECTIFIER GENERATOR

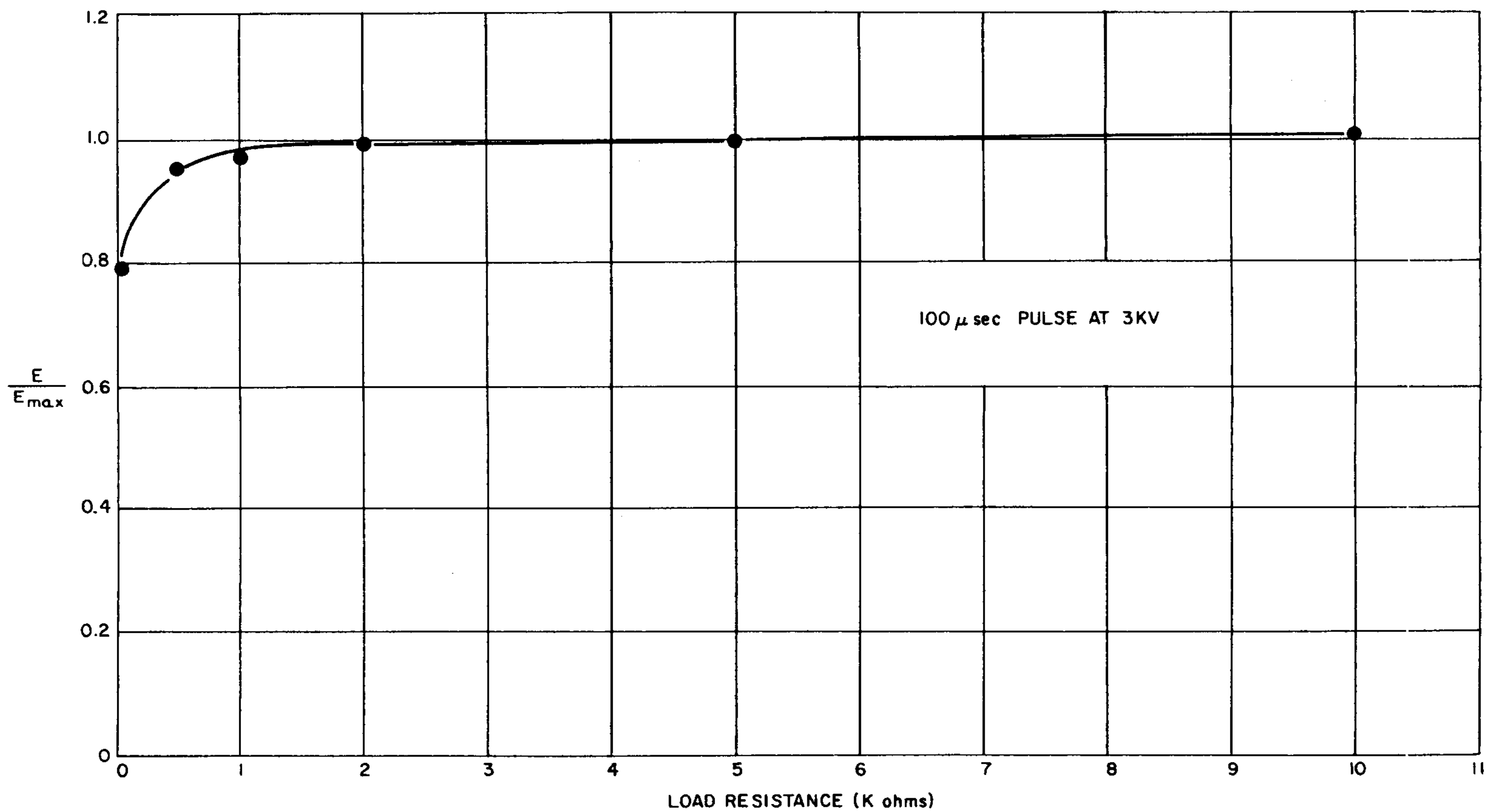


FIG. 3-3. VOLTAGE REGULATION OF PFN GENERATOR
(Constant Voltage Mode)

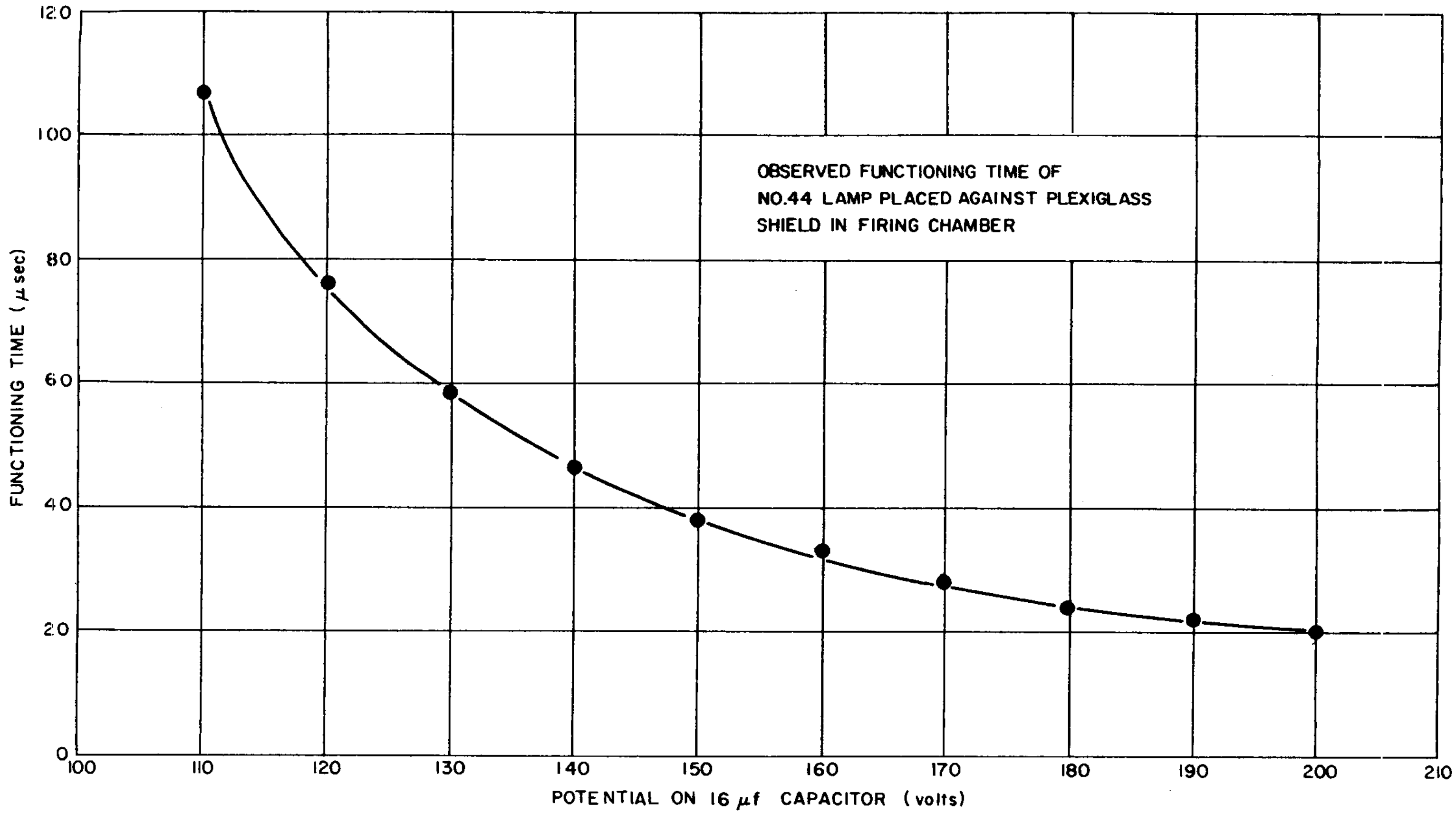


FIG.3-4 FUNCTIONING TIME CHECK

As a general rule, only the most sensitive devices are fired by capacitor discharges or by constant voltage pulses. In this category are carbon bridge devices, and a few wire bridge devices. There are, however, exceptions. Low resistance devices (one ohm or less) are usually fired by constant current pulses, from either the SCR or PFN generators. Exploding wire devices require an EBW generator; here there is no choice.

Select the chosen generator with the GENERATOR switch on the MAIN CONTROL chassis(p-2).

3.3 Mounting the Initiator; Safety Practices

It is generally a good practice to have the initiator electrically shorted and kept in a metal container affording adequate separation between initiators to prevent propagation from one to the next. We use drilled aluminum blocks for this purpose. There is always a danger of initiation from static charges and from radio frequency sources. RF hazards are minimized by avoiding strong RF fields, either by keeping the distance great or by shielding the area in which initiators are handled. The cure for static is to avoid concentration or migration of electric charges. The operator and his surroundings must be grounded as should be the container for the initiators. It is a good practice to keep the initiator leads shorted. Static discharges can cause detonation when a potential difference is applied between the shorted leads and the case, as well as between leads when the short is not present, so precautions must be taken against static charges.

The firing chamber (p-11) provided with this equipment has, at its right side, a safety switch. This switch must be down when the initiator is being loaded. In this position the firing lead to the initiator is disconnected from the firing line and connected to ground. Thus, the initiator connections inside the box are shorted and grounded. Now the initiator may be connected to the circuit.

The mounting requirements are so varied that a universal mount for all devices is not possible. Two wires have been run into the firing chamber of this equipment. Connections from this point are to be provided by the user. The mount should be designed so that the initiator is in line with the flash detector port.

Connection having been made, the firing chamber door is closed and the safety switch moved up. All testing procedures can then be carried out from the equipment console.

3.4 Measuring Resistance

To measure resistance first select the measuring current to be used: 10 microamperes, 1 milliampere, or 10 milliamperes. Selection is made by the MEASURING CURRENT switch on the Main Control unit (p-2). The choice depends upon the maximum permissible current and the desired resolution in the measurement. Only the most sensitive devices (carbon bridges and conductive mixes) need be limited to 10 microamperes. All known wire bridges may safely be measured with one milliampere and most will withstand 10 milliamperes without problems. One milliampere is recommended for most applications and will probably receive the greatest use and 10 milliamperes is appropriate for EBW devices, which have low resistance.

The ohmmeter must be checked and standardized periodically during operation. The standardizing procedure is simple and fast, and once learned requires just a few seconds to complete.

Allow a few minutes for the equipment to warm.

1. Select the desired measuring current on the MEASURING CURRENT switch (p-2).

2. On the DC MICROVOLT-AMMETER, (referred to as Pre-amp), set the FUNCTION switch to Voltage, the AMPLITUDE control full clockwise, and the RANGE to 10 millivolts (p-7).

3. On the DIGITAL VOLTMETER (the DVM), set the RANGE switch to Auto and the sample rate control to full counter clockwise (p-7).

4. Calibrate the DVM by pressing the INT. CHECK switch and adjusting the front panel set screw to the value indicated (p-7).

5. Press the Ohmmeter Zero push button and adjust the Zero Control on the Pre-amp so that DVM reads zero (p2,p-7).

6. Push the key switch on the panel to STANDARDIZE, and adjust the appropriate OHMMETER CURRENT ADJUST control until the DVM reads 1.000 (p-2).

If the 1.000 reading cannot be thus obtained, three trimming controls are provided (screw driver adjustment below the knobs) to compensate for component aging. If none of the controls can bring the meter to the proper current reading, the 47-volt mercury battery needs to be replaced (p-12).

7. Depress the key to MEASURE and read on the digital display, the resistance of the device in the firing chamber.

The full-scale resistance reading of the display may be obtained simply by dividing the voltage range setting of the HP-425 microvolt-ammeter by the measuring current. For example, with 1 milliampere and a range of 1-volt on the preamplifier, the full scale reading is 100 ohms. For a one-ohm full scale reading with a measuring current of one milliampere, the one-millivolt range setting should be used. The chart in the lower right of the Main Control (p-2) will give the proper decimal location at a glance.

The meter scale on the pre-amplifier (that is, the DC MICROVOLT-AMMETER) is an indicator of ohmmeter performance. In general, it is well to keep this meter on scale. If the meter is overdriven, moving up-scale on the preamplifier will usually bring the meter back on scale. If the meter cannot be brought back on scale by setting the range, it means that the initiator circuit is open. Resistance accuracy is best when the meter scale indicates between 0.1 and full scale. The DVM reading should duplicate the meter scale reading numerically.

The use of a precision resistor in the firing chamber will both check operation of the equipment and provide good practice for the operator.

3.5 Rectangular Pulses from the SCR Generator (p-14)

Operation of the SCR generator is brought about by turning the function switch on the Main Control panel to the SCR position. Most of these tests will be constant current, but there is a choice of either constant current or constant voltage operation on the SCR mode switch located beneath the pull-out desk top. For constant current operation this knob should be turned to one of the five series-resistor positions located on this panel. The largest possible resistance of the five resistors should be used, to achieve the greatest current regulation. Maximum current available is determined by dividing the chosen resistance plus one ohm into the maximum voltage on the power supply. Current limits are as follows:

Table 3-1

CURRENT RANGE FOR VARIOUS SERIES RESISTANCES
(SCR Generator)

Resistance Setting	Maximum Current
160	1.07
60	2.6
30	5.3
15	10.6
5	31.0

The equipment can deliver 50 amperes or more, bypassing the resistors, but with some sacrifice in regulation. In no case should conduction be allowed through the circuits for indefinitely long times and without someone in attendance of the equipment.

Current amplitude is controlled by the voltage of the main power supply. Two controls are available. One is for rough adjustment and the other for fine. When setting current amplitude a long pulse time should be used in order to allow the digital voltmeter (DVM) to read current. The DVM is introduced into the circuit by turning the DIGITAL VOLTMETER control on the Main Control panel to SCR Output Current. In this position the DVM reads the voltage drop across a one-ohm resistor in series with the load and hence the current directly in amperes.

A dummy load resistance that is as near to the resistance of the item being tested as possible should be selected for setting the current initially. This value may be selected from those available on the load resistance selector switch located on the DUMMY LOAD PANEL with the key switch at TEST, the FIRE switch may be operated and the current amplitude will be indicated on the DVM. This current may be brought to the desired value by adjusting the main power supply.

The current having been adjusted, we go next to pulse width adjustment. Pulse width is measured with the counter, which is connected into the circuit by setting the SYNC switch on the main control to Gate and the FUNCTION switch on the counter to per B. The pulse application time will be read directly on the counter. The time indicated in this case will be that of the phantastron timing generator. An alternative, particulary useful for short pulses, is to set the SYNC switch to Firing Line. In this position the counter will read the duration of current application to the dummy load resistor.

At this point both the current amplitude and the pulse application time will have been adjusted. All of these preliminary adjustments will have been made with the Test-Operate switch in the TEST position. To operate, move this switch down to OPERATE, and all is ready to expose the initiator to the firing pulse. All that needs to be done is to depress the FIRE switch on the main control.

Functioning time measurements will be discussed elsewhere, but in this case all that is required is to turn the function switch on the counter to Time B-A before the FIRE switch is depressed, and functioning time will be indicated on the counter.

The waveform may be observed on the built-in oscilloscope by turning its selector on the MAIN CONTROL to FIRING LINE.

Constant voltage operation of the SCR generator is obtained by turning the SCR Mode Selector to any one of the four shunt resistor positions. The shunt chosen depends upon the resistance of the device being tested, and should be less than about one-tenth the resistance of the device being tested. This implies that no EED with a resistance less than one ohm be tested with constant voltage pulses, nor should the current drain on the power supply ever exceed 50 amperes. The inherent limit on constant voltage testing is 50 volts with the 0.1 ohm shunt. Always present in the constant voltage mode of operation is a one-ohm resistor in series with the power supply and the combined shunt and load resistance.

To adjust amplitude, switch in a shunt that is about 0.1 times the resistance of the device being tested. With the key switch at TEST and the DIGITAL VOLTMETER selector switch at SCR/RAMP Output Volts, select the dummy load nearest the resistance of the device being tested by means of the LOAD RESISTANCE selector switch. Press the FIRE switch with a long pulse time set on the PULSE WIDTH control and observe the pulse voltage on the digital voltmeter. This sets the voltage amplitude. The oscilloscope may be used to measure the amplitude of short pulses, utilizing the differential comparator.

To set pulse time, follow the same procedure outlined for current operation. Once the time is properly set, the initiator can be exposed to the pulse by pushing the key switch to OPERATE and then depressing the FIRE switch.

3.6 Pulse Forming Network (PFN) Generator

The lower limits of time on rectangular pulses from the SCR generator are somewhat greater than 100 microseconds. To allow testing with rectangular pulses of duration 100 microseconds or shorter, it is necessary to use the PFN Generator.

To do this, first select the PFN position on the GENERATOR switch on the MAIN CONTROL. Then select the pulse time desired from the PULSE WIDTH selector on the PFN Generator. The mode switch on the PFN Generator panel will most generally be used in the constant current position. It may, however, be used in the constant voltage position if the resistance of the device being tested is well over 500 ohms. For constant current operation the device should be less than 5 ohms and preferably less than one-ohm.

The PFN must be charged from the precision power supply, and it may be charged to the full 3000-volt output of this supply. Amplitude of the output pulse is determined by the setting of the power supply.

For setting the amplitude of the PFN generator, the load resistor nearest that of the device being tested should be selected from the load resistance selector switch, with the TEST-OPERATE switch in the TEST position. The FIRE switch can be depressed and the waveform viewed and calibrated using the oscilloscope. The OSCILLOSCOPE selector should be at FIRING LINE VOLTS to view the pulse. The Type Z plug-in unit supplied with the oscilloscope is specially adapted to measure pulse amplitude accurately and the use is fully described in the Tektronix Manual supplied. Current amplitude is the voltage divided by the load resistance.

After the amplitude is satisfactory, firing is accomplished by throwing the TEST-OPERATE switch to Operate, and depressing the FIRE switch.

3.7 Capacitor Discharge Generator

The capacitor discharge generator is selected for use by turning the GENERATOR switch on the MAIN CONTROL to the C.D. position. The SYNC switch should be on Firing Line.

The capacitor is chosen from behind the pull out panel of the generator. The values of capacitance available are clearly marked and choice is made inserting the luminous, two-pronged plug into the marked value of capacity. A spare position is provided in case a capacitor of a different value is required.

The amplitude level may be chosen from the precision power supply used to change these capacitors. Over-voltage protection is provided for the capacitors; these are rated at 1000 volts with the exception of the 16 microfarad capacitor that is rated at only 200 volts. It is well to keep below these rated values during testing even with the protection provided.

The potential to which the capacitor is charged can be read on the DVM. This can be done by turning the DIGITAL VOLTMETER Selector to the Charging Volts position. In this position there is a 10 to 1 reduction in voltage from the capacitor line to the digital voltmeter. (With 100 volts on the capacitor, the DVM would read 10.00 volts.) The digital voltmeter reading is more reliable than the meter on the power supply; there is a small difference in the two readings. If the difference is large, it would be well to investigate the reason.

A calibration is provided for the capacitor discharge section of the equipment that can be extremely useful in detecting troubles in the operation of this generator. This will be discussed later in this section of the manual.

With capacitor and amplitude chosen and set, the initiator may be exposed to the firing pulse, by depressing the Fire key.

C.D. CAL position

Setting the GENERATOR switch to C.D. CAL connects a vacuum thermocouple across the output of the C.D. generator.

In addition, the PREAMP (on the panel marked DC MICROVOLT-AMMETER) is connected to the secondary, or DC output side of the thermocouple.

The PREAMP acts as a ballistic galvanometer and will give repeatable deflections of the meter face upon discharge of a selected capacitor at a certain applied voltage.

For this calibration procedure there must be no load on the firing line. This can be accomplished by not connecting an initiator in the Firing Chamber, or by using one of the OPEN positions on the DUMMY LOAD switch.

For this, the TEST-OPERATE key must be in the TEST position.

Table 3-2 shows the charging voltage for each capacitor to give full scale meter deflection on the PREAMP, with the 1 millivolt range.

Table 3-2

CAPACITOR AND POTENTIAL FOR 1 MILLIVOLT DEFLECTION FROM C.D. TEST

Capacitor (microfarads)	Potential (volts)
16.0	8.0 volts
1.0	32.0 volts
0.7	38.5 volts
0.4	51.0 volts
0.1	101.7 volts
0.01	330.0 volts
0.004	542.0 volts
0.0022	775.0 volts
0.001	Over 1000 volts, Do Not Check

Extreme caution must be observed not to exceed the charging voltage listed for a particular capacitor. Too high a voltage will destroy the thermocouple. The charging voltage is read on the DVM. Don't forget to multiply the DVM reading by ten, as noted earlier in this section.

These figures are an indication of the transfer efficiency of the C.D. generator. Any major deviation from the chart may be due to any of several things

1. Loose Connectors
2. Defective mercury plunger relay
3. Change in capacitor value
4. Worn banana plugs on selector plug
5. Insulation breakdown causing leakage

These should be thoroughly checked if deviation is noted in these readings.

3.8 Exploding Bridgewire (EBW) Generator

This generator can test EBW devices with any one of three values of firing capacitance, selected by a link connection behind the front panel. The four possible connections of the link are 1, 2, and 10 microfarads, plus and External capacitor as required.

The generator is brought into operation by turning both the GENERATOR switch and the SYNC switch to EBW. The firing leads to the remote relays must be changed for operation of the EBW unit. Remove the normal input to the remote relays marked SCR/RAMP, PFN, C.D. and connect the EBW cable to the input marked EBW.

Power for this unit is derived from the 3000-volt power supply and the full 3000 volts may be used without any difficulty.

The charging voltage on the firing capacitor is measured by the DVM, when the switch on the Main Control is set to Charging Volts. The voltage indicated will be one tenth that on the capacitor.

Firing is accomplished by depressing the FIRE switch.

3.9 Slope Generator

A constant current ramp ranging from 10-milliamperes per second to 4000 amperes per second may be generated with this equipment. Current range is from 100 milliamperes to 20 amperes and the direction is from 500 microseconds to 10 seconds.

The TEST-OPERATE switch should be on Test, The GENERATOR Selector on SCR/RAMP, the SCR/RAMP Generator Function switch to RAMP. The SCR mode switch may be set to any constant voltage position. A dummy load nearest the resistance of the device to be tested should be used.

To set up the ramp both Ramp Balance and Ramp Amplitude controls should be at zero, full counter clockwise. At this point select the Ramp Current Range. The current specified is available only with a load resistance of one ohm or less; however, the generator may be used for loads with resistance as high as 10 ohms with decreased maximum current.

Next set the DIGITAL VOLTMETER switch on the Main Control to Charging Volts and adjust the 160 volt power supply to 32 volts.

Note that automatic overvoltage protection (operating at 40 volts) is provided to protect the semiconductors in the generator; none the less, the power supply should be off when switching from SCR to Ramp operation.

Switch the OSCILLOSCOPE switch on the Main Control to Ramp Drive. Push the button marked PUSH to DISCONNECT SIGNAL on the oscilloscope preamplifier, Section A and center the spot vertically with the POSITION control. Now adjust the RAMP ZERO control with a screw driver, while repeatedly depressing the FIRE key; adjust so that the start of the slope begins at the zero voltage position. This adjustment is a stable one, and will rearely need to be repeated.

With the DVM switch set to Ramp Zero, the digital voltmeter will read about 9.4 volts.

Set the DIGITAL VOLTMETER switch to Ramp Balance, and turn the RAMP BALANCE control clockwise until the DVM suddenly reads the power supply potential, and then back off several turns.

Now set the OSCILLOSCOPE selector to Ramp Output Current. The differential (A-B) mode must be used (selected by the switch on the oscilloscope preamplifier) and both A and B gain controls must be at the same setting for the next step. The output current may be read directly from the oscilloscope by applying the correction factor obtained from the RAMP CURRENT RANGE switch on the generator. Adjust the output current using the RAMP AMPLITUDE control. Adjust both BALANCE and AMPLITUDE controls to give the best waveshape. The slope may be expressed numerically as the maximum current divided by the pulse duration. Both RAMP AMPLITUDE and PULSE WIDTH controls affect the slope.

Functioning time is best obtained directly from the oscilloscope because there is a delay between the beginning of the gate signal and the beginning of the output pulse. The timer and flash detector may be used to obtain functioning time, but it is necessary to subtract the interval between the gate signal and the start of rise from the time read on the counter.

Due to feedback in the network of the ramp generator, the slope is constant as long as the generator is not required to deliver more than 20 volts across the load.

Table 3-3

FUNCTIONS OF SWITCHES AND CONTROLS ON MAIN CONTROL PANEL

Digital Voltmeter

Position	Use
Charging volts	Reads power supply voltage ÷ 10 except on SCR/Ramp - reads direct
SCR Output Current	Reads voltage across 1-ohm resistor, hence current, for long constant current pulses
SCR/Ramp output volts	Reads voltage across firing line terminals on SCR/Ramp generator
Ramp Current	Reads output current of long current ramps. On 20 amp range multiply reading by 2 to get amps; on 4 amp position, divide reading by 2-1/2.
Ramp Zero	Used for initial setup of Ramp. Should be about + 10 volts when ramp unit is on and idling.
Ramp Balance	Used to set up ramp - Ramp Balance is set below the point where voltage increases to supply voltage.
DVM Direct	Allows voltmeter to be used with front panel jack; low side is internally grounded.

Oscilloscope

Position	Function
EBW Volts	Reads approximately 1/100 of EBW Voltage at firing unit
EBW Current	Reads 1/10 of Voltage across .05 ohm resistor
SCR/Ramp Gate	Used to get indication of pulse width of SCR - not calibrated for voltage
Firing Line Volts	Reads 1/10 of output voltage except on EBW
SCR output Current (Must be used differentially) (A&B, Gain equal)	Reads voltage across 1 ohm resistor (disregard spikes at leading and trailing edges as they do not appear at firing line).
Ramp output current (Must be used differentially)	In 20 amp position, reads 1/2 the output current. In 4 amp position, reads 2.5 times the output current.
Ramp Drive	Negative ramp - used to set up ramp initially.
Timer Stop	Reads 1/10 of voltage of Flash Detector used to check operation and measuring functioning time.
Test Point	Connects input to panel jack marked SCOPE TEST POINT. Used for adjusting 10 to 1 attenuator.

Table 3-3 (Cont.)

SYNC

Position	Function
Firing Line	To start timer and oscilloscope sweep with leading edge of firing pulse. (Use on C.D., PFN, and SCR below 500 microseconds.)
SCR/RAMP Gate	Used to measure functioning time when using SCR or RAMP. To measure pulse width or ramp time set TIMER to PER B.
EBW	To start TIMER and oscilloscope sweep about 1/2 microsecond before firing pulse.

Table 3-4

SWITCH SETTINGS FOR TYPICAL OPERATION

Switch on MAIN CONTROL Panel

Output	Generator	DVM	Oscilloscope	Sync	Power Source	Notes
Capacitor Discharge (Low-Energy)	C.D.	Charging Volts*	Firing Line Volts	Firing Line	High Voltage 0-1000 only	200 V max on 16 mfd capacitor
Capacitor Discharge (High-Energy, Low-Impedance Output)	EBW	Charging Volts*	EBW Current (Reads E across .05 Resistor) EBW Volts (approx. 10% of output voltage)	EBW	High Voltage 0-3 KV	Sync is 1/2 microsecond before firing pulse. EBW volts should be used only for comparison
Rectangular Pulse (less than 100μsec)	PFN	Charging Volts*	Firing Line Volts*	Firing Line	0-3 KV High Voltage	Select constant voltage or constant current
Rectangular Pulse, 200 μ second to 11 seconds constant current	SCR/Ramp	SCR output current (reads in amps)	SCR output current must be used differentially	SCR/Ramp Gate	0-160 V (Choose highest series resistance which will deliver the required current)	Set up with timer function switch on "period B". Check timer with oscilloscope on SCR output current
Rectangular Pulse 200 μ second/11 seconds constant voltage	SCR/Ramp	SCR/Ramp output volts	Firing Line Volts*	SCR/Ramp Gate	0-160 V (Choose lowest shunt resistance permitting required voltage; do not exceed 50 amp from power supply)	Adjust output parameter on dummy load. Use 2-11 sec. range of width range
Constant Current Slope	SCR/Ramp	Charging Volts	----	----	0-160 V set to 32 V	Step 1. SCR Mode to constant voltage
	Function Switch to Ramp	Ramp Current	----	----	-----	Step 2. Adjust balance control 2 turns counterclockwise for point of voltage jump
4 amp max	----	----	Ramp output current. Must be used differentially. amps= 2 x voltage indication	SCR/Ramp Gate	-----	Step 3. Adjust Amplitude and balance for line at trace of desired amplitude
20 amp max	----	----	Ramp output current. Must be used differentially. amps= 0.4 x voltage indication	----	-----	------

*Indicated voltage is 1/10 of Actual Voltage

4. FILUP II CIRCUIT DESCRIPTION

4.1 General

The Franklin Institute Laboratories Universal Pulser, Model II, consists of several discrete pulse generators described earlier. These are controlled from a central control chassis, called MAIN CONTROL. This unit also selects and switches the various measuring and monitoring functions, and applies these to the test and measurement instruments.

The individual pulse generators will each be described in detail. The MAIN CONTROL will be discussed last. In this way interrelationship of the various components will be better understood.

Each chassis and instrument has been assigned a number, and each part has been assigned a part number of which the chassis number is a constituent. The schematic drawings indicate these numbers.

These numbers are also shown on the block diagram and cable interconnection drawing. Note that each cable has been assigned a number that does not bear any relationship to the chassis numbers.

The cable numbers are matched to the connectors on each chassis. These cables and connectors have been tagged and labeled with their respective numbers to facilitate connecting this equipment.

The power service requirements for FILUP II are as follows. A 208 volt, three phase, three wire service is required. It is desirable, but not absolutely necessary to have a 4th wire neutral. The current required from this service is 28 amperes, but it is considered wise to provide 35-ampere conductors. A 115-volt, 60 cycle service is required with a ground connection. The power required is 1300 watts and the current 12 amperes. The service connection should provide 20 amperes. An effective equipment ground is essential to the operation and safety of this equipment.

The various generators will be designated in these notes, abbreviated as follows:

PFN = Pulse Forming Network Generator, Chassis 200

CD = Capacitor Discharge Generator, Chassis 300

EBW = Exploding Bridgewire Generator, Chassis 400

SCR/RAMP = Silicon Controlled Rectifier/Ramp Generator, Chassis 900

In addition the Digital Voltmeter will be referred to as the DVM, the Microvolt-Ammeter as the PRE-AMP, and the Berkeley "EPUT" meter as the TIMER.

4.2 PFN Generator, Chassis 200

This generator consists of a multisection pulse forming network, a charging source, and a relay for discharging the PFN into the initiator.

The selected section of the PFN is charged to the desired voltage through resistors R201, R202, R203 and R204 and through S202.

The charging voltage is indicated by the DVM, which is connected to pin H of J201.

Resistors R205 through R210 form a ten-to-one voltage divider. These resistors were selected to take into account the input impedance of the DVM (10.2 megohms) which is in parallel with R205. The divider was designed to incorporate standard value resistors, and has several resistors in series to withstand the 3000 volt potential maximum in the generator. The ten to one divider is necessary, since the top limit of the DVM is 999.9 volts and as much as 3000 may need to be read. Identical dividers are in the CD and EBW Generators.

To discharge the PFN through the initiator, the FIRE key is closed, operating the relay pair, K701-K702. The normally open contacts of K202 discharge the PFN through the load, and the normally closed contacts of K201 open after a half second delay, releasing K202. The purpose of this arrangement is to limit the time of connection of the load to the changing source, which remains connected to the PFN, through 400 kilohms. The diodes CR201 and CR202 are transient suppressors, used across all relay coils in FILUP II.

The closure of K202 discharges the PFN either through or across R210 depending on the setting of the MODE switch (S201). For position 1, CONSTANT CURRENT, the 50-ohm resistor R210 is in series with the output J204. For position 2, CONSTANT VOLTAGE, the resistor R210 is grounded and J204 is connected to the high end of R210.

4.3 Capacitor Discharge Generator, Chassis 300

The CD generator consists of nine capacitors, selectable by a plug arrangement, and a combination of several relays to perform a certain definite sequence of charging and firing. These relays operate in such a manner that at no time can the power source be connected directly through the initiator. This is important in the case of some highly sensitive initiators. In addition, there is only a very short time between disconnection of the charging source and the closure of the fire relay (K304). This insures minimum energy loss from the capacitors, particularly the smaller values, due to leakage.

In detail, the circuit operates as follows:

The state of the circuit, as drawn, corresponds to an open interlock condition. One of these interlocks, S301, is actuated by the door over the capacitor selection plug. The interlocks, which are all in series, disable the 24V dc power supply in the POWER CONTROL chassis 800. There are six interlocks; three are on the rear cabinet doors, one in the FIRING CHAMBER, one in the EBW chassis, and one in the CD chassis presently under discussion.

All of the interlocks except the one in the firing chamber, can be defeated by pushing in the actuator and turning it clockwise. They will automatically reset themselves when the doors are shut.

The 24 volt supply is connected through pin A of J301. With an open interlock circuit, there is no 24 volts available and all the relays are open. This grounds the capacitor through R308 and K303; the high voltage power supply is also isolated, by the series pair of contacts of K302. K302 is a three-contact mercury-wetted relay. Two of the contacts are in series to withstand up to the 1000 volts maximum permissible in the chassis.

Upon application of 24V dc to Pin A, K303 is energized, removing the safety ground from the capacitor bank. At the same time K302 is energized through the normally closed contact of K301. This connects the charging source through J302, R301, and R302, and contacts A and B of K302, to selected capacitor. Contact C is now open.

The DVM divider consists of R304 through R307. VR 301 is a controlled avalanche diode, actually a high voltage Zener diode. This limits the charging voltage to the capacitor to slightly above their 1000 volt rating.

The 16 microfarad capacitor C309 is rated at only 200 volts. VR302 and VR303 are voltage regulator tubes that will conduct at about 210 volts thus limiting the applied voltage to that particular capacitor.

Closing the FIRE key applies 24 V dc through Pin B to relay K301, whose operation releases relay K302. This disconnects the charging source (J302) and energizes relay K304.

By having relay K304 operated by this release of K302, the capacitor cannot be discharged to the load until it is disconnected from the power supply; there is an interval of about 100 milliseconds, due to the operation time of K304. Through this sequence the operation of the firing key provides a capacitor discharge through J303 into the initiator.

When the FIRE key is released K301 and K304 are immediately deenergized. In order to insure that the charging source is not reconnected to the capacitors while K304 is still closed, K301 waits one second before releasing. Thus K302 will not be energized until the one second period has elapsed.

4.4 EBW Generator Chassis 400

The EBW chassis comprises primarily a GL7171 Ignitron V401, three capacitors C401, C402, C403, of 1, 2, and 10 microfarads respectively, having 3000 volts maximum voltage rating, and an Ignitron firing circuit. Its circuit is such that the load, including cable, holding fixture, and initiator, must remain ungrounded.

The high voltage, adjustable 0-3000 volts, enters on J402 and charges the selected capacitor through the charging and isolating resistors, R401 and R402. R403-407 form the divider for the DVM as in the PFN and CD chassis. Transformer T402 and its associated components make up a power source of about 800 volts DC. This charges the Ignitron Capacitor C404. Closing the FIRE key actuates K401, applying the charged capacitor C404, to the Ignitron between the ignitor electrode and cathode. R418 (2.7 ohm) prevents erratic firing.

The type RG8 output cable is connected directly to the cathode and the shield of the cable connects to the high side of the .05-ohm current shunt, R408. The current shunt is a special design consisting of approximately 56, 1 watt resistors, 2.7 ohms each, mounted between the periphery of two heavy brass plates. The exact number of resistors is determined during fabrication so that the end resistance is exactly .05 ohms. This shunt exhibits very low inductance and high power handling capacity for this application.

The oscilloscope is connected to the CUR jack (J403) to monitor the discharge current.

Also in the cathode circuit of the ignitron is a string of resistors forming a 10 to 1 voltage divider, the output going to J404. This provides a means of observing the voltage waveform on the oscilloscope. Since the divider ratio was not adjusted in manufacture, the oscilloscope cannot be used to measure voltage at points on the wave.

R414-R417 take a portion of the output pulse to provide a sync signal to start the TIMER AND OSCILLOSCOPE, by way of connector J405.

R421 is a specially constructed heating element on the anode of the ignitron to keep it warmer than the cathode. This prevents condensation of mercury on the anode which could cause misfiring.

This heater is always on whenever the FILUP is turned on. The 800 volt power supply is on only when the EBW generator is in use.

4.5 Power Control, Chassis 800

This unit contains the main power switch, fuses, auxiliary ac receptacles, a 24 volt dc power supply and relays to disconnect the 24 volts and also the high voltage power supply. The circuit is straightforward and requires little explanation.

Both relays are controlled by the interlock circuits.

K802 is a single pole mercury plunger relay, it disconnects the 24 V dc from the firing circuits. K801 is a two pole mercury plunger relay with one normally open and one normally closed contact; when the interlock circuit is open, the high voltage lead to the main control chassis (at J813) is grounded through R801 and R802. When relay K801 is operated by closure of the interlocks, the lead from J813 is ungrounded and connected to the high voltage power supply.

4.6 Power Supply Unit Chassis 1000

This is the large power supply, NJE model EA-160-50, modified. Originally it was a Y-connected variable auto transformer bank, feeding, through fuses, three single phase output transformers.

The schematic shows the modification. The lines between the original large voltage control and the 3 phase transformer at the right of the drawing were broken to introduce the VERNIER circuit.

T1101 is a small, three gang variable autotransformer, whose outputs are connected to the primaries of T1102-1104 respectively. The 5-volt secondaries are series aiding in each of the three phases. Turning up the VERNIER powerstat adds an additional 5 volts to the main transformer primaries thus providing fine control.

4.7 Remote Relays Chassis 600

The small box adjacent to the FIRING CHAMBER contains two mercury plunger relays, each with two normally open poles and one normally closed pole.

These relays in conjunction with K101 (in the MAIN CONTROL) make the connections necessary for resistance measurements.

The schematic shows the relays in the remote relays box; the K101 relay in the MAIN CONTROL and the safety switch on the FIRING CHAMBER area also shown for convenience. The notes on the diagram of the MAIN CONTROL, chassis 100, are pertinent to a discussion of this relay chassis, since the REMOTE RELAYS are controlled from the MAIN CONTROL. The OHMMETER key and the TEST-OPERATE key are both related to the operation of the REMOTE RELAYS.

The ohmmeter system of the FILUP II utilizes the four-wire measuring system, two wires to supply a constant current and two wires to read potential directly across the measured resistance. This system will be discussed in detail in the notes on the MAIN CONTROL. The purpose of the REMOTE RELAYS is to make the connection of the measuring system as close as possible to the initiator in the FIRING CHAMBER. Furthermore, the relays also isolate the firing lines from the measuring circuits, which could be damaged by the high power pulses which may appear.

All the relays are shown in deenergized, as when firing the initiator. The OHMMETER circuits, which are on J603, pins B, C, D, E, are all disconnected from the firing circuits and are also shorted. Energizing the relays connects the ohmmeter circuits to pins A and B of J601, the firing chamber connection.

K101, in the MAIN CONTROL, is in the position shown when firing. However, if the pulse were being delivered to the DUMMY LOADS, then K101 would be in the other position. This is controlled by the OPERATE-TEST key on the main control.

The OHMMETER key, in the MEASURE position operates K601 and K602; it also operates K101 regardless of the setting of the OPERATE-TEST key.

For the special case of EBW tests, the EBW generator output cable is connected to J605 and the cable to J602 is disconnected. To avoid switching or breaking into the EBW firing line, it is connected directly through to J601, pins C and B. The EBW generator does not affect the accuracy of the OHMMETER even though it is not disconnected during resistance measurement.

The SAFETY SWITCH on the FIRING CHAMBER will short out the EBW firing line and the initiator when in the down, or safe position. The other firing line (C.D., PFN, SCR/RAMP) is disconnected when the EBW Generator is in use. The SAFETY SWITCH must be in the up position to measure resistance under all conditions, EBW or otherwise.

4.8 SCR/RAMP Generator 900 Chassis

This generator consists primarily of a phantastron timing circuit, a silicon controlled rectifier with related start and stop circuits, and a high power transistor amplifier for the ramp. The ramp is derived from the phantastron, as is the rectangular pulse. The silicon controlled rectifier is utilized for both ramp and rectangular (SCR) operation. Note that there are two SCR's. The important one here is SCR901.

V901 and V903 form a phantastron; operation is conventional, and described in many texts. This circuit generates both ramp and rectangular signals from 200 microseconds to 10 seconds in duration. The ramp is taken from the plate, and the rectangular pulse from the screen of V901.

S903 and R906 are used to set the pulse width. V902B is a cathode follower that provides a low impedance input to the phantastron timing components and to the ramp drive to the transistor amplifier. V902A is also a cathode follower that feeds a turn-on signal to the gate of SCR901 for ramp operation and also a rectangular pulse for sync and duration measurement, through J904 to the start input of the TIMER and the sync input of the oscilloscope.

Consider first the operation of the SCR/RAMP generator in the SCR function, for rectangular pulses.

The seven pole two position FUNCTION switch, S901, will be in the position other than that shown on the drawing. The positive-going square wave from V902A is amplified by V904, and differentiated by C914 and R929. The derived positive pulse, which is coincident with the start of the rectangular pulse, is applied to the grid of thyratron V907. In the plate circuit of V907 is a pulse-shaping network, L901, C918, C919 charged to 300 volts through R933. It is discharged through V907, and the roughly rectangular pulse voltage developed across R934 is applied to the gate of SCR901 through current limiting resistor R936.

This starting pulse must be shorter in duration than the minimum "on" time of the SCR, 200 microseconds; otherwise the SCR may continue to conduct even after the stop signal is applied. The network produces a pulse that drops to zero in less than 100 microseconds. If a capacitor alone is used in place of the network, the gate signal might not drop to zero in time.

The stop pulse is derived from the trailing edge of the rectangular pulse from the phantastron. V905 takes the positive pulse from the grid of V902A, amplifies and inverts it. C915 and R928 differentiate the now negative-going rectangular wave. A differentiated negative pulse produces a positive going pulse at its trailing edge and this is fed to V906, a 2D21 thryratron. C916, charged to 300 volts, is discharged through V906 across R932. The resulting pulse turns on SCR902 which discharges C917. One side of C917 is connected to the anode of SCR901, and when SCR902 conducts the other side of CR917 is in effect dropped to ground potential. The heavy current discharge is in opposition to the normal current flowing through SCR901 to the output circuit and initiator. This reduces the current below the holding value long enough to shut off SCR901. CR901 assists the opposing current in getting to SCR901 and also reduces any negative signals on the firing line.

At this point the drawing SCR MODE SWITCHING should be referred to. This shows the output circuit of the SCR/RAMP generator.

The 0-160 volt power supply feeds the anode of SCR901 by way of J901, then through R1001, which is connected to J905. R1001 is the 1 ohm current-measuring resistor; it also provides enough isolation of the 160 volt power supply to permit the stop signal to turn off SCR901. Without this isolation, the low output impedance of the large power supply shorts out the stop signal.

The cathode of SCR901 is connected through pin A of J903, and of PL1001 to the series and shunt resistors, R1002 -- R1006, inclusive.

The first four positions of S1001 short out the series resistors and connect segments of R1006 across the line. PL1001, pin B, is grounded in the SCR/RAMP chassis by way of pin B of J903 and pin G of S901. Positions 5 through 9 of S1001 insert the series resistors in the firing line, the output side being pin C of PL1001.

The output signal goes into and out of the SCR/RAMP chassis through pin C of J903 and pin W of J902. The output then goes to the MAIN CONTROL.

RAMP Operation

Switch S901 performs all the switching from SCR to ramp operation. The switch, S901, is shown in the RAMP position.

The RAMP action begins at the plate of the phantastron, V901, and continues through cathode follower V902B. R909 through R913, and particularly R911, form a zero-balancing arrangement that sets the starting voltage of the ramp signal. R911 is the RAMP ZERO, a front panel control.

The ramp signal next goes to the RAMP AMPLITUDE control which sets the drive level to Q901, an emitter follower. Q901 feeds Q902 through R940 and related resistors. This circuit sets the proper operating point of Q902 and also the following stages. The feedback voltage is injected at the base of Q903, which is an amplifier and phase inverter that drives Q904. Q904 is operated as an emitter follower and is capable of supplying sufficient current to drive the output stages. Q905-Q909, five paralleled current amplifiers. The five collectors tied together carrying the 20-ampere ramp output.

When S902, the RAMP CURRENT RANGE switch, is in the 4-ampere range, the output of the first four transistors, Q905-Q908 is diverted through R960. Q909 alone is connected to the output. This is done to preserve the bias and feedback conditions.

Each of the five output transistors has a network of three resistors, (R950, R961, R962 in the case of Q905) that in addition to setting the proper voltage and current parameters, also develop the feed back signal. This feedback voltage is fed back to the base of Q903 of as mentioned before.

The various Zeners and diodes in the circuit are all protective devices for the transistors. They protect the various transistor elements against transients and polarity reversals.

The ramp output is fed to the anode of SCR901 through S901D. At the start of the ramp the rectangular gate signal from V902A turns on SCR901 and holds it on for the duration of the ramp. At the end of the ramp the gate signal goes off and the SCR no longer conducts since the residual current from the transistor amplifier is below the minimum holding current of the SCR. This circuit was included since the idling current from the transistor ramp amplifier would be excessive for some types of initiators. The SCR leaks only about 2 microamperes in its nonconducting state.

The cathode of SCR901 is connected to the SCR MODE switch, S1001, as for SCR generator operation. However, the SCR MODE switch must be in one of the CONSTANT VOLTAGE positions for RAMP operation.

S901G disconnects the lower end of R1006 for RAMP operation. This results in the SCR MODE switch and the associated series and shunt resistors being out of the circuit entirely for RAMP operation.

The RAMP amplifier is powered by the same power supply used for SCR operation. Since this supply can go up to 160 volts and anything over about 40 volts will destroy the transistors, a protective circuit has been incorporated.

The transistor amplifier is designed to work at 32 volts. The 0-160 volt supply enters through J901, pin A, then S901A, then through the normally closed contact of K902 to the amplifier.

The coil of K903 is in series with a Zener diode, VR902, across the supply line, ahead of S901A. At about 40 volts the Zener conducts and K903 pulls in, which in turn pulls in K902, disconnecting the supply line from the transistors. This also lights the RAMP OVER VOLTAGE pilot

(DS901) through S901B. The 24-volt relay supply, which operates K902, is not affected by the interlocks. Although K903 and K902 will operate, even during the SCR function, anytime the supply voltage is above 40 volts, both K903 and VR902 were selected to handle the full voltage, 160 volts, continuously, without overheating. Even if the FUNCTION SWITCH, S901, is thrown to the RAMP position while the power supply is set too high, the protection will be effective. It is, nevertheless, still advisable to turn the power supply down to zero before switching to ramp operation. This practice eliminates any possibility of switching transients causing damage to the semiconductors.

The various bias and plate voltages are fed through and controlled at the MAIN CONTROL chassis, which will be discussed next.

The bias voltages are taken from a small power supply in the MAIN CONTROL; the 300 volt supply is the LAMBDA model 28 power supply, at the left lower part of the rack.

4.9 MAIN CONTROL Chassis 100

This chassis is the switching and control section for the FILUP II. It consists of switches, relays, the ohmmeter circuit, and calibration circuits.

The drawing of the MAIN CONTROL shows all switches and relays in their normal position where applicable. This means that spring return switches and push buttons are shown in their released position. These are S106, S104, and S108, and relay K101.

The multideck switchs S101, S102, S103 have their decks designated by letters, starting with A nearest the front panel.

The key switch, S104, has its contact arrangement shown on a separate drawing.

S109 and S110 are small sensitive switches mounted on S101; they are actuated only when S101 is at position 5.

S105 has two poles on one deck. The hexagons with similar letters indicate common connections.

S104, the STANDARDIZE-MEASURE switch, is a three-position key switch with spring return to the center position from either the up or the down position. This will be referred to as the ohmmeter key.

When the key is held down in the MEASURE position only the upper set of contacts transfer. These are designated D1 to D10. In the upper, STANDARDIZE, position the lower contacts only transfer. These are designated U1 to U10.

The MAIN CONTROL works as follows.

The GENERATOR switch S101 has six decks and five positions.

Deck A switches the high side of the digital voltmeter for measuring the charging voltage of the various generator chassis. This is picked up on the DVM switch S102, position 1.

Deck B switches the 24 volts dc from the FIRE key S106, to the selected generator.

Deck C switches 115V ac to the various generator chassis.

Deck D switches the 0-3 KV power supply to the proper generator.

Deck E and Deck F are in parallel (except on position 5, C.D. CAL).

These decks select the outputs from the generator chassis. They are in parallel to accommodate the heavy currents and to keep the contact resistance low.

In position 3, S101 selects the EBW generator. The output of the EBW generator has its own cable which does not go through the MAIN CONTROL. Therefore, in this position, the switch grounds the output line merely as a precaution against stray pickup. Position 4 and 5 of S101 select the C.D. generator. The function of every deck except deck E is the same for both positions. Deck E, in position 5, switches the output pulse from the C.D. generator to the "primary" or input of the thermocouple, TC101, which is mounted directly on the switch deck. In this location, the thermocouple is readily accessible for replacement; if this becomes necessary, note a coding of red point on one lead, and connect the new one correspondingly.

The wipers of S101, decks E and F, are joined, and connected to K101. This is a two pole mercury plunger relay used as a single pole, double throw relay.

K101 transfers the output line either to the DUMMY LOADS through J102, or to the FIRING CHAMBER through J101. It is controlled by the TEST OPERATE key, S107, and also by the OHMMETER key, S104, in the MEASURE position. This was mentioned in the section covering the REMOTE RELAYS. Regardless of the position of the OHMMETER key S107, S104 in measure position will pull in K101.

<u>The DIGITAL VOLTMETER or DVM switch, S102</u>, switches the high and low input of the DVM for its various functions. Deck B switches the high side and deck A the low side. The low side is grounded for all positions except 2 and 4.

Position 1, CHARGING VOLTS, picks up the wiper of S101, deck A, for measuring the charging voltage. Position 2, SCR OUTPUT CUR, connects the DVM high and low inputs across the 1-ohm current measuring resistor, R1001. The DVM measures the voltage drop differentially. R1001 is connected to pins G and H of J107. It is located in the bottom of the cabinet. Position 3, SCR/RAMP OUTPUT VOLTS, connects the DVM high side to the output of the SCR/RAMP generator and measures the voltage to ground.

Position 4, RAMP CUR, connects the DVM differentially across the emitter resistor, R958, of Q909 in the SCR/RAMP generator.

Position 5, RAMP ZERO, connects the DVM to the arm of the RAMP ZERO control R911, in the SCR/RAMP generator.

Position 6, RAMP BAL, connects the DVM to the collector of Q909 in the SCR/RAMP Generator.

Position 7, DVM DIRECT, disconnects the high input of the DVM from any internal circuits permitting use of the front panel input on the DVM directly. This is useful for troubleshooting. The low side is grounded internally by S102. If it is desired to use the DVM differentially using its front panel input, it is necessary to remove the input plug at the rear.

The oscilloscope switch, S103, selects, in some cases, the same circuits as S102, the DVM switch. This switch is used in conjunction with the 10:1 attenuator, R118-120 and C102; this attenuator is sometimes necessary, to reduce the pulse amplitude sufficiently to avoid overloading the oscilloscope preamplifier. On positions 5 and 6 this attenuator is shorted out by deck B, so that the readings are direct.

Deck C of S103 connects the -B input of the oscilloscope to the SCR/RAMP generator, in positions 5 and 6, for differential measurements. In the other positions, the -B input is left floating and the A input is effectively measuring to ground.

Position 1, EBW VOLTS, connects the oscilloscope input to the 10:1 cathode divider of the ignitron in the EBW generator. The two dividers give a total attenuation of 100:1.

Position 2, EBW Current, connects the .05 ohm shunt, R408, in the EBW chassis. The voltage drop measured here must be multiplied by 200 to give the true pulse current.

Position 3, SCR/RAMP GATE, connects the output of V902A in the SCR/RAMP chassis.

Position 4, FIRING LINE VOLTS, connects the output line for all except the EBW generator.

Position 5, SCR OUTPUT CURRENT, connects the scope differentially across the 1-ohm current measuring resistor usually used for the DVM; this permits measuring pulses too fast for the DVM to follow. On this position do not multiply by 10. The differential voltage measured equals the current in amperes directly.

Position 6, RAMP OUTPUT CURRENT, permits a differential measurement across the emitter resistor of Q909, (R958). This again duplicates the DVM reading on position 4 of S102. The formula on the RAMP CURRENT RANGE switch plate must be used to get the true current. The 10:1 attenuator is not in the circuit at this switch position, hence the voltage measured on the oscilloscope is a direct reading.

Position 7, RAMP DRIVE, connects the oscilloscope to the same circuit as the DVM, when its switch S102 is in position 5.

It provides a picture of the ramp drive signal to the transistor amplifier. This is used in adjusting the RAMP generator.

Position 8, TIMER STOP SIGNAL permits viewing the stop signal from the flash detector, or other transducer. It provides a rough measurement of the functioning time as a check on the operation of the TIMER.

Position 9, TEST POINT, connects the A input directly (through the attenuator) to the SCOPE TEST POINT on the front panel. This is used in conjunction with the calibration output on the oscilloscope to adjust the 10:1 attenuator trimmer capacitor C102. This adjustment is called SCOPE ATTEN. ADJ. The scope Test Point may also be utilized as a utility input to the oscilloscope. Of course the probes supplied with the oscilloscope can be connected directly into the scope preamplifier.

SYNC Switch S111 selects synchronizing, or starting signals for both the TIMER and the OSCILLOSCOPE sweep. This circuit includes a clipper to limit the maximum voltage of these signals. The clipper consists of R121-R122 and VR102, a 6.8 volt zener Diode, and provides protection to the measuring equipment. It also eliminates frequent resetting of trigger level and sync controls since it fixes the level of the signals under most conditions.

Position 1, FIRING LINE, selects the sync signal directly from the firing line for all cases except the EBW generator. This position should be used for pulses shorter than 500 microseconds from the SCR/RAMP generator.

Position 2, SCR/RAMP GATE, selects the gate signal from V902A in the SCR/RAMP chassis. This signal may be used to measure the "period" of the gate, either on the TIMER or the OSCILLOSCOPE. Since the waveform deteriorates somewhat below about 500 microseconds it is best to use an actual firing pulse into a DUMMY LOAD for period measurements.

Position 3, EBW, selects the pulse from the ignitor circuit of the Ignitron in the EBW generator. This pulse is about 1/2 microsecond ahead of the discharge through the ignitron. Thus the beginning of the output pulse will be slightly delayed along the base line of the scope sweep, permitting better observation of waveforms.

The OHMMETER key, S104, performs all the necessary switching operations for measuring resistance. Some of this switching is indirect through associated relays controlled by S104.

The key switch has three positions with spring return to center. The schematic shows S104 in the center position.

When the key is pushed down to the MEASURE position only contacts D1 to D10 transfer, and when the key is in the STANDARDIZE position contacts U1 to U10 transfer.

With S104 in the central, or neutral position, the following conditions prevail.

The DVM input is connected to the DVM switch, S102, through contacts U1, U2, D1, D2.

The input to the PRE-AMP, J105, is shorted.

The current and potential leads to the REMOTE RELAYS are grounded. (J123, B,C,D,E).

The shorting and grounding protect the measuring instruments from transient pickup during firing. The circuit from the FIRE switch, S106, is connected to S101 through contacts S104, D8 and U8. This insures that no firing can occur while the OHMMETER key S104, is being pushed up or down.

With the OHMMETER key, S104, in the up or STANDARDIZE position the circuit is set up as follows:

The input to the PRE-AMP high side is connected to S105 wipers, by way of S104-U3. The PRE-AMP low side goes to the junction of R106, R107, R108, by way of S104-U5; and the negative side of BT101, the 47 volt battery, is connected to the same point by way of S104, U4. Under these conditions the PRE-AMP can now measure the voltage drop across the selected standard resistor, R106, R107, or R108.

The output of the PRE-AMP is connected to the input of the DVM by means of contacts U1 and U2 of S104. Note that S104-U8, is opened, thereby disabling the firing key circuit.

When the OHMMETER key is pushed down to MEASURE the following occurs.

Now only contacts D1 to D10 transfer. Contact D6 connects the wiper of S105A to J123B (positive current line). Contact D4 connects the battery negative to J123C (negative current line). Contact D3 connects the PRE-AMP high input to J123D (positive potential line). Contact D5 connects the PRE-AMP low input to J123E (negative potential line). Contacts D1 and D2 connect the output of the PRE-AMP to the DVM input. Contact D8 disables the firing key circuit. Contact D9 applies + 24 VDC to the relays in the REMOTE RELAYS box. Contact D10 closes K101 coil circuit.

Note that contact D9 and D10 will have no effect if the FIRE key is held down while the OHMMETER key is depressed.

The preceding actions apply the selected measuring current to the initiator in the FIRING CHAMBER. The input to the PRE-AMP is also connected to the initiator by its own set of two leads. At the same time the firing circuits are disconnected, disabled and isolated. This is all necessary to prevent damage to the resistance measuring circuits from the firing pulses.

Note that there is no current drain from the battery, BT101, unless the OHMMETER key is held up or down and even then it can be no more than 10ma. Under these conditions the battery should last for at least two or three years.

R110, R113, R116 are the small trimming resistors just below the OHMMETER CURRENT ADJUST controls. As the battery voltage drops, due to age, these trimmers can be adjusted to bring the OHMMETER CURRENT ADJUST controls into range.

The OHMMETER ZERO pushbutton S108, disconnects and shorts the PRE-AMP input and connects the output directly to the DVM input. This permits adjusting the ZERO control of the PRE-AMP for zero reading on the DVM.

5. MAINTENANCE

The FILUP II has been designed to require a minimum of maintenance. Where feasible all parts and components have a large reserve factor with respect to heat dissipation and power rating.

The most important item of routine maintenance is to keep the OSCILLOSCOPE filter clean. Refer to the TEKTRONIX manual for this procedure.

All the purchased components and instruments have their own manuals and these should be utilized to their fullest in order to keep the FILUP II in best operating condition.

Of particular importance is the TEST procedure for the BECKMAN EPUT-TIMER. This takes about one minute to check. This should be gone through at least once a day. See page 8 of the EPUT manual. It is quite easy to adjust the EPUT for proper operation as the manual shows.

Also important is the periodic check of the oscilloscope preamplifier gain adjustment as discussed in its manual, page 2-1 of "Type Z Plug-in" manual.

The ROTRON fan in the SCR/RAMP generator should be oiled as shown on the GOLD SEAL MUFFIN FAN instructions, a copy of which is in Appendix D of this manual.

All of the chassis have long cables and they may be pulled out of the rack while still operative.

The schematic for the SCR/RAMP generator (S-12) shows voltages readings taken under the following conditions. (The DVM was used to take these measurements.) The first conditions are for the vacuum tube circuits. The second for the transistor amplifier.

Table 5-1

CONDITIONS FOR VOLTAGE MEASUREMENTS ON SCR/RAMP GENERATOR

Control	Setting
0-160 V Power Supply	Off
Pulse Width Range	2-10 MS
Pulse Width	Max.
Ramp Current Range	4 amp position
Ramp Balance	CCW
Ramp Amplitude	CCW
Generator Selector (Main Control)	SCR/RAMP
Function Switch	SCR
Sync	SCR/RAMP GATE

For measurements on the transistor amplifier, set the 160 V Power Supply to 32 Volts, and the FUNCTION switch to RAMP.

Every few months check and tighten all connectors and the connections to the large power resistors mounted in the rack. This includes the DUMMY LOADS.

If the key type switches become stiff after long operation a drop or two of oil on the cam mechanism of the levers will restore their smooth operation. These key switches are the FIRE, TEST-OPERATE, and OHMMETER.

The large rotary switches should have their contacts lubricated periodically. No specific time can be designated for this operation since it depends on frequency of use. Lubrication is indicated when the switches become stiff. A small quantity of BEACON LUBRICANT 325, MIL-G-3278A, applied only to the areas of actual contact is recommended. A light silicone grease may be used instead. These switches include the DUMMY LOADS, SCR/RAMP FUNCTION, PFN MODE, and PULSE WIDTH, SCR MODE, and GENERATOR (on Main Control).

Access to the SCR MODE switch, below the pull-out writing surface, can be had easily by removing the knob and the four panel screws. The panel will come off exposing the switch.

When reinstalling, tighten the knob set screws securely with the allen wrench supplied.

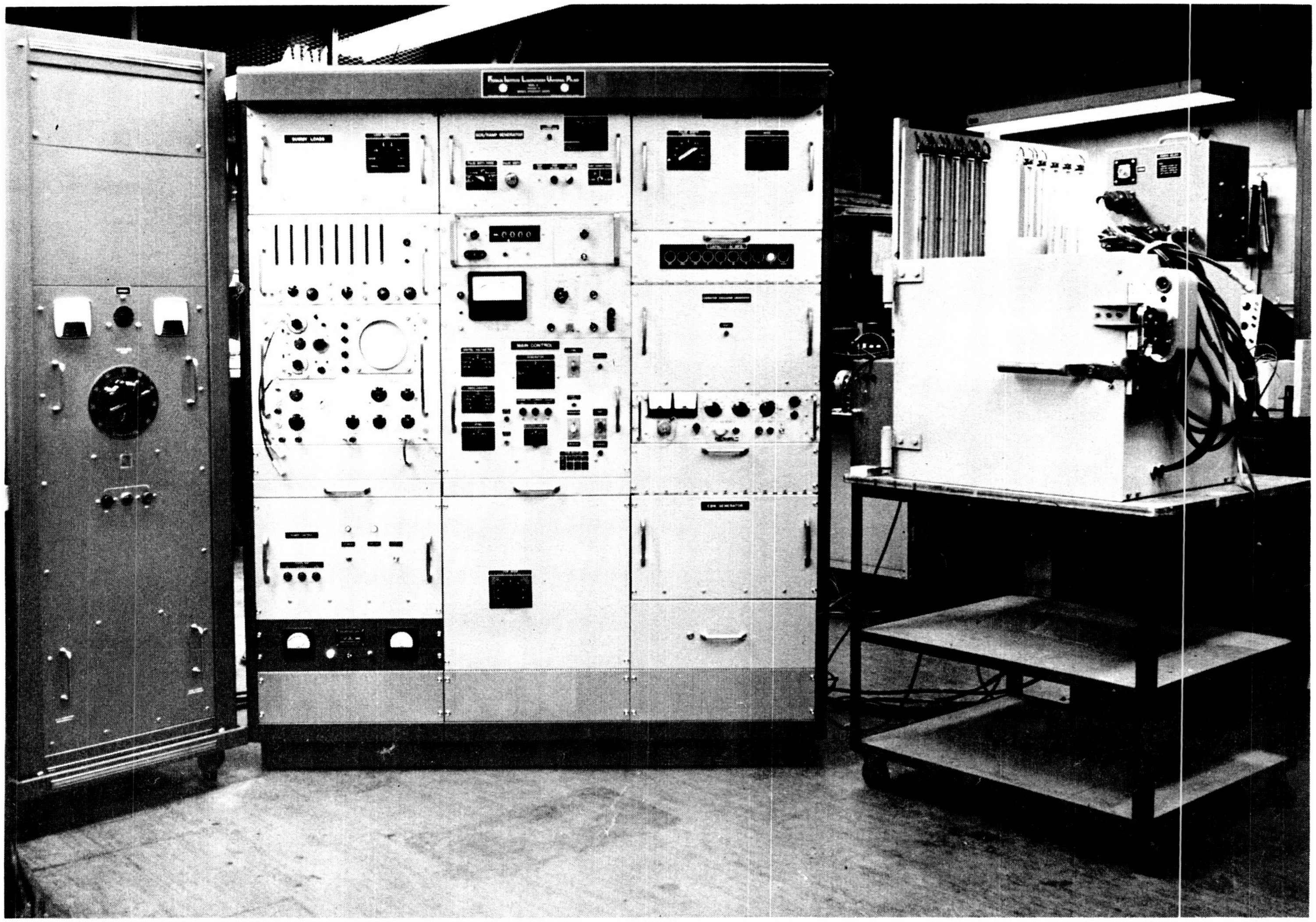
There are measures that can be taken to check operation of the equipment to be sure operation is normal or to determine the need for maintenance or repair. Some of these have been mentioned previously. Section 3.1 gives regulation curves and information on the timing checks using light-bulbs. Checking these will reveal flaws in equipment operation.

The CD-Cal features allow a quick operational check of the transfer efficiency of the capacitor discharge generator.

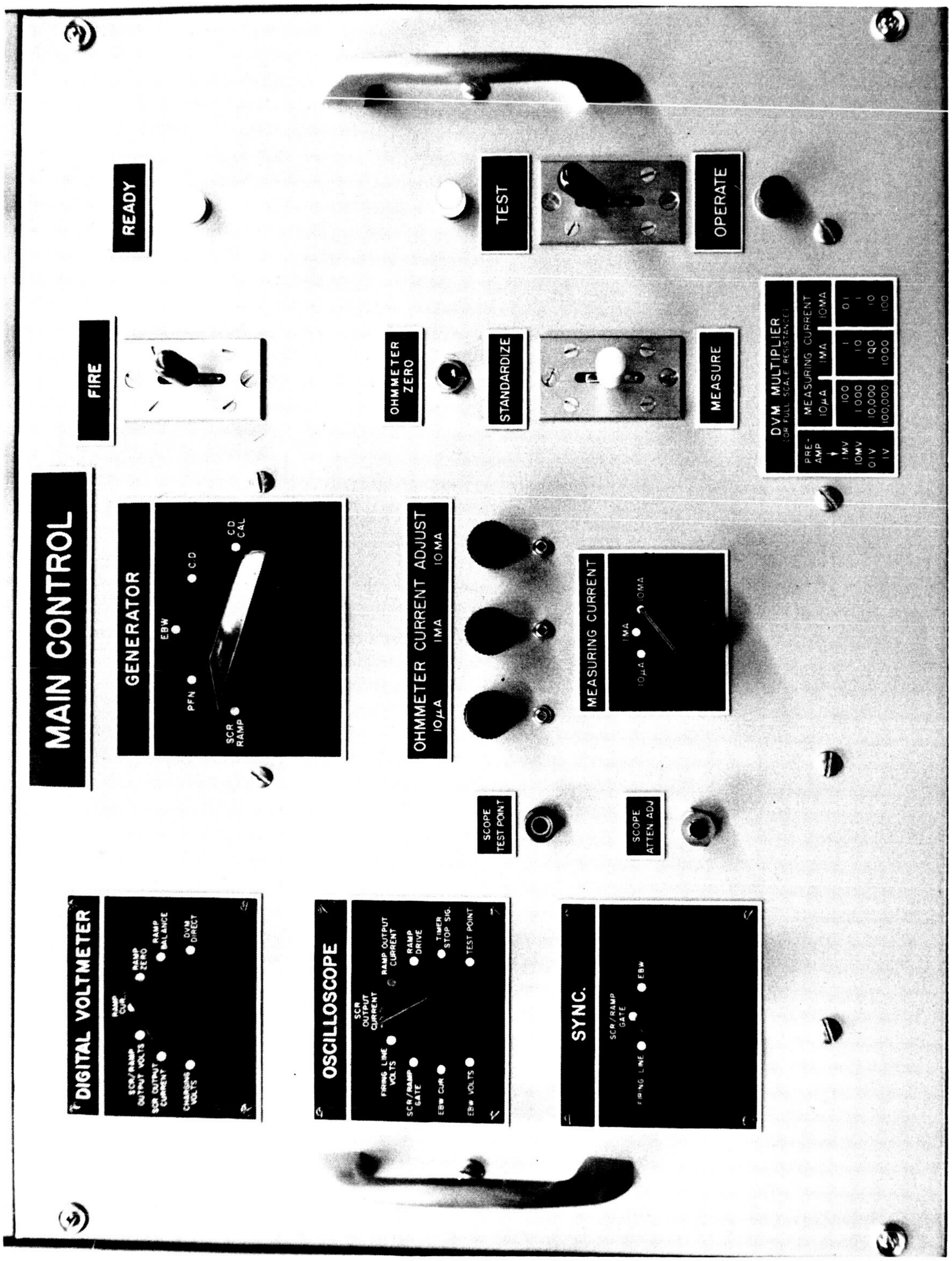
The oscilloscope and digital voltmeter are equipped with switch connections to various locations throughout the equipment. Advantage should be taken of this feature for location, isolation and repair procedures.

APPENDIX A

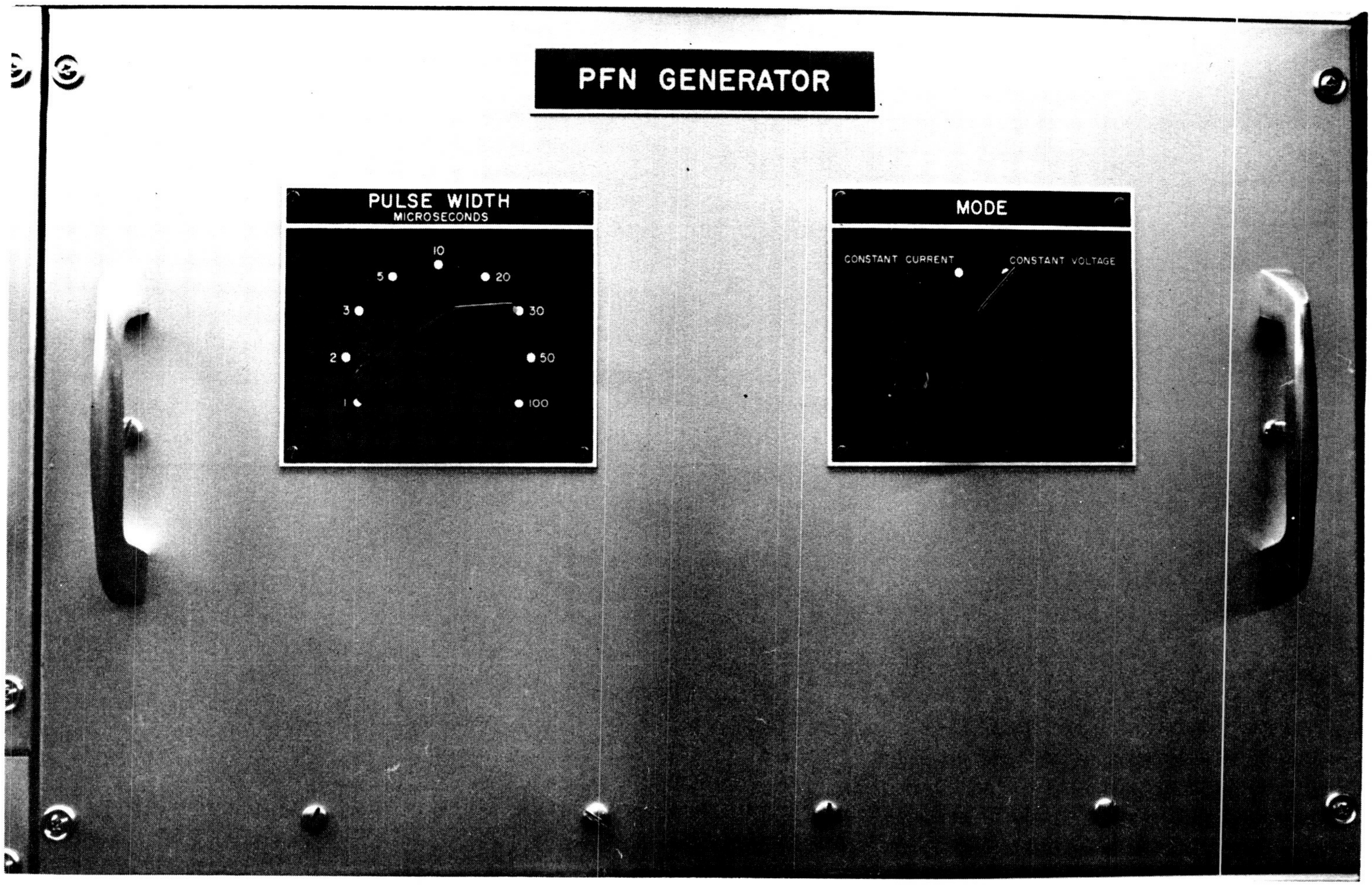
PHOTOGRAPHS



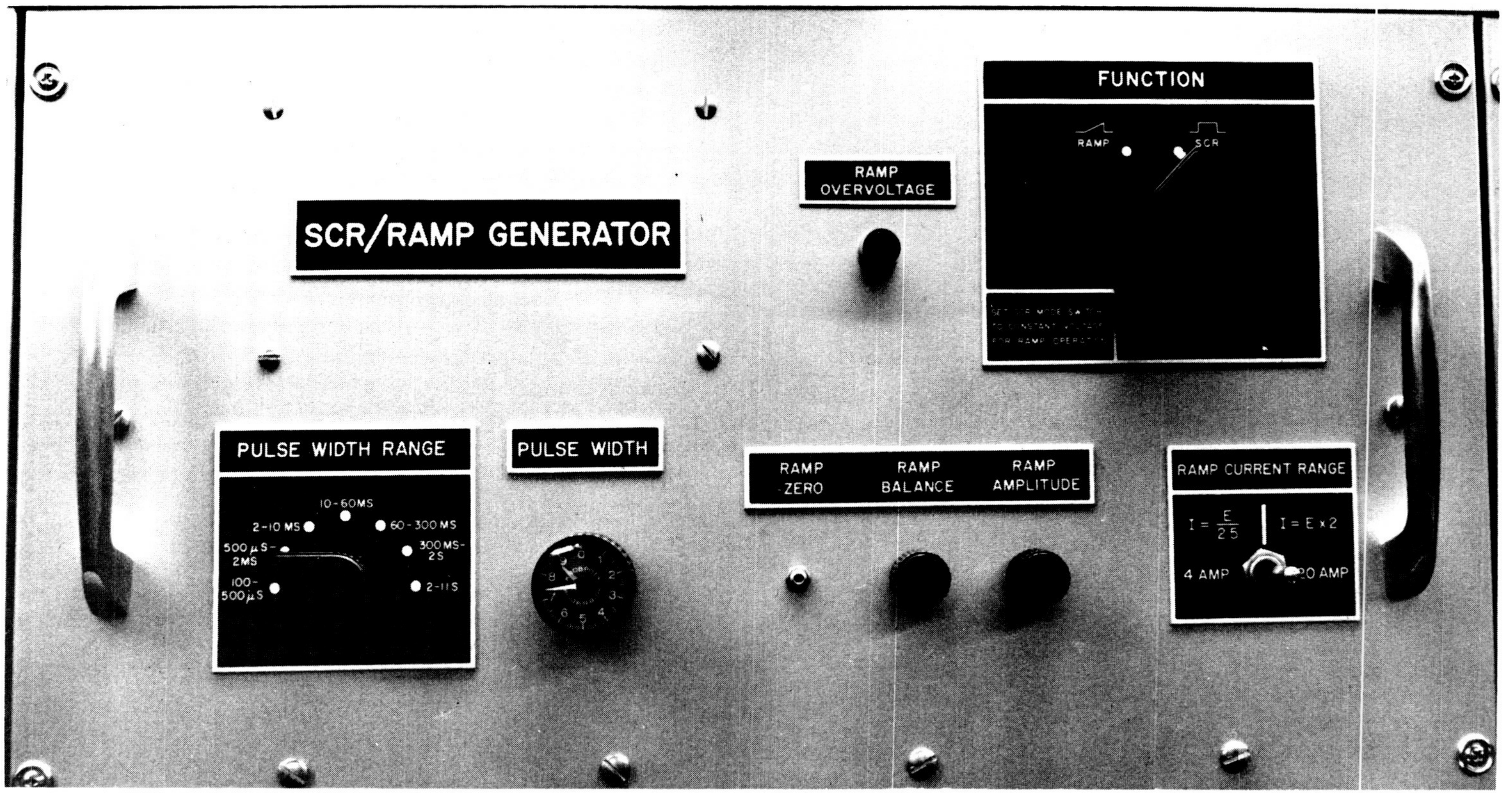
P-1 - COMPONENTS OF FILUP-II EQUIPMENT



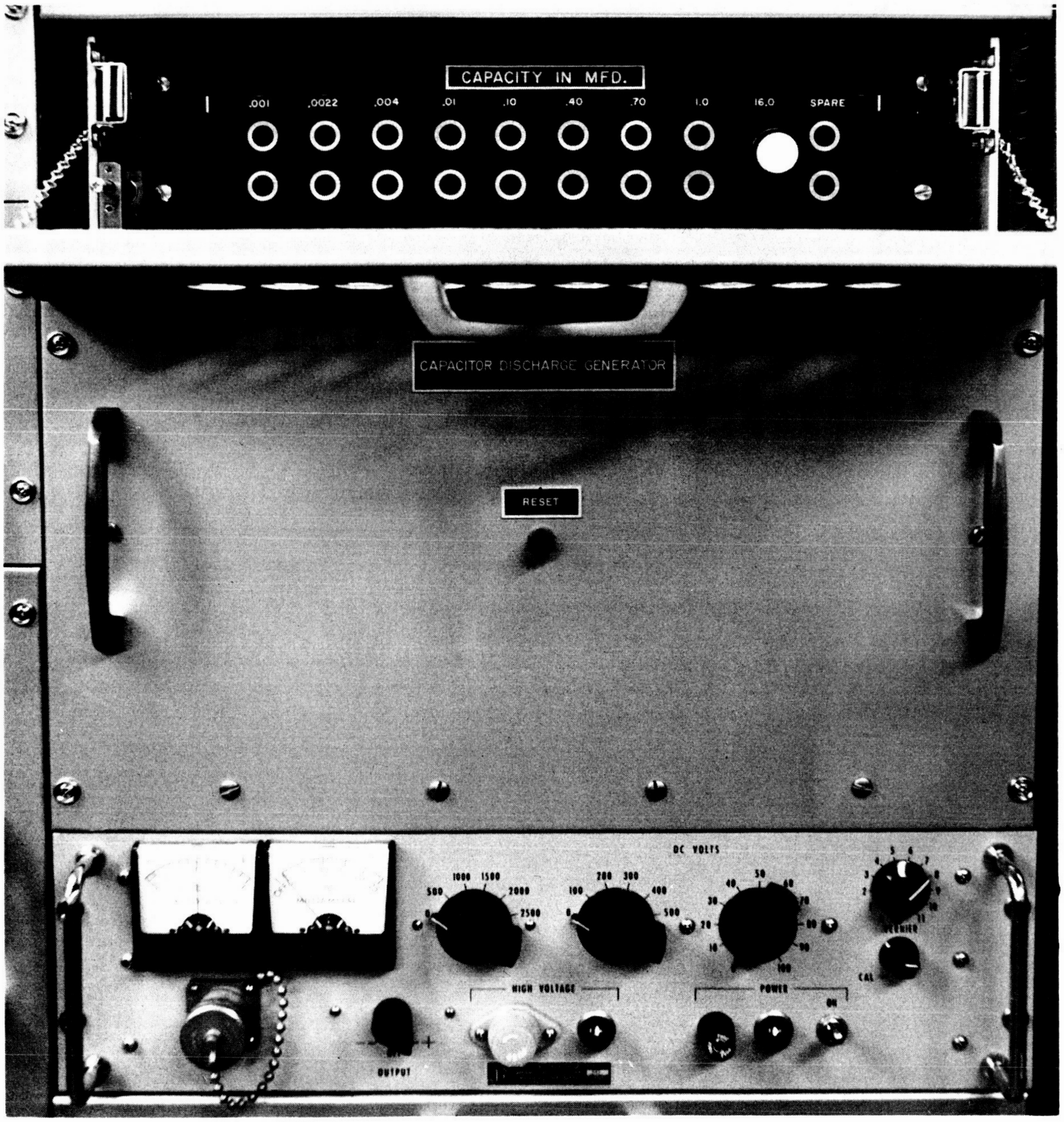
P-2 - MAIN CONTROL



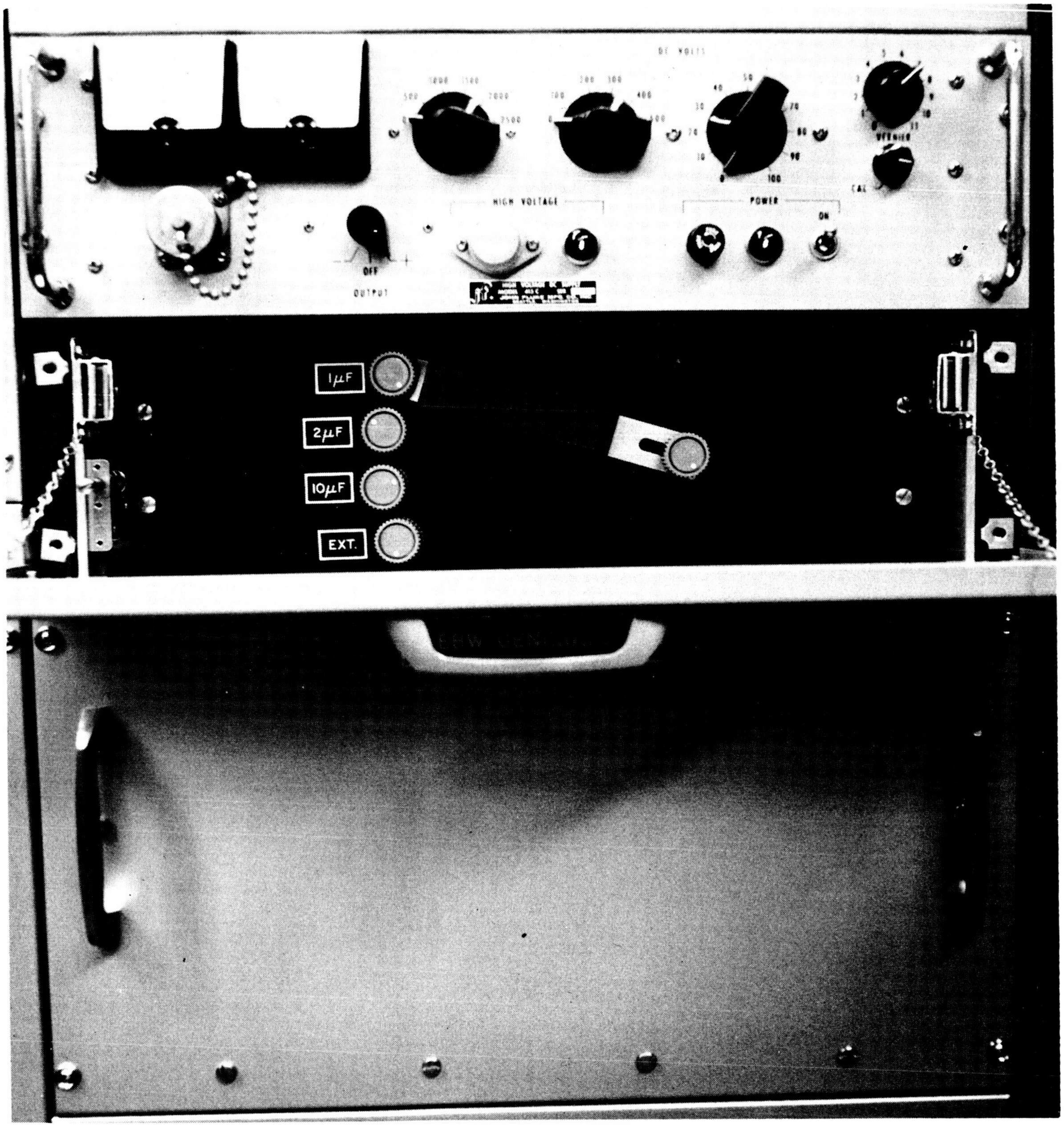
P-3 - PFN GENERATOR



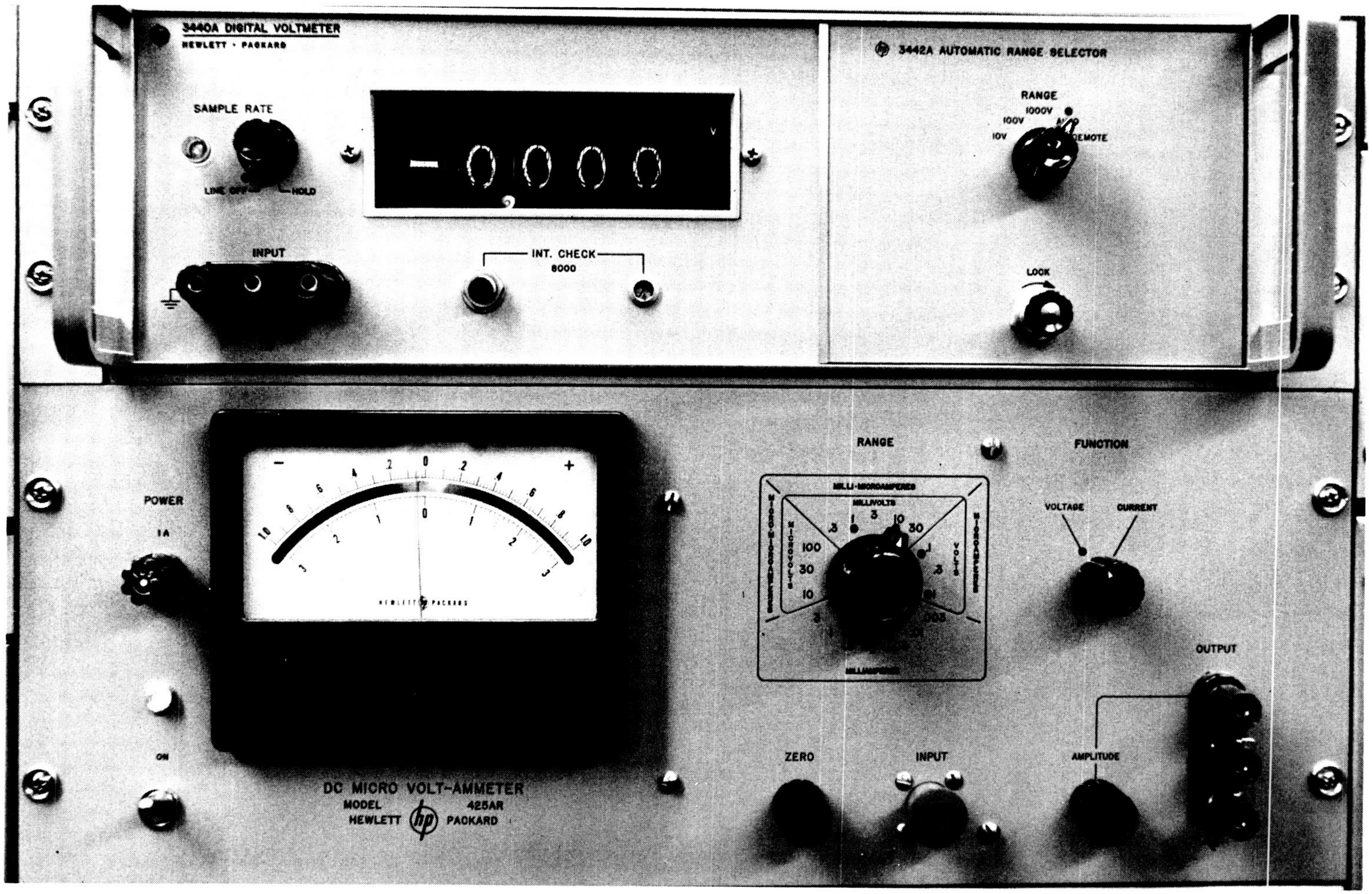
P-4 - SCR/RAMP GENERATOR



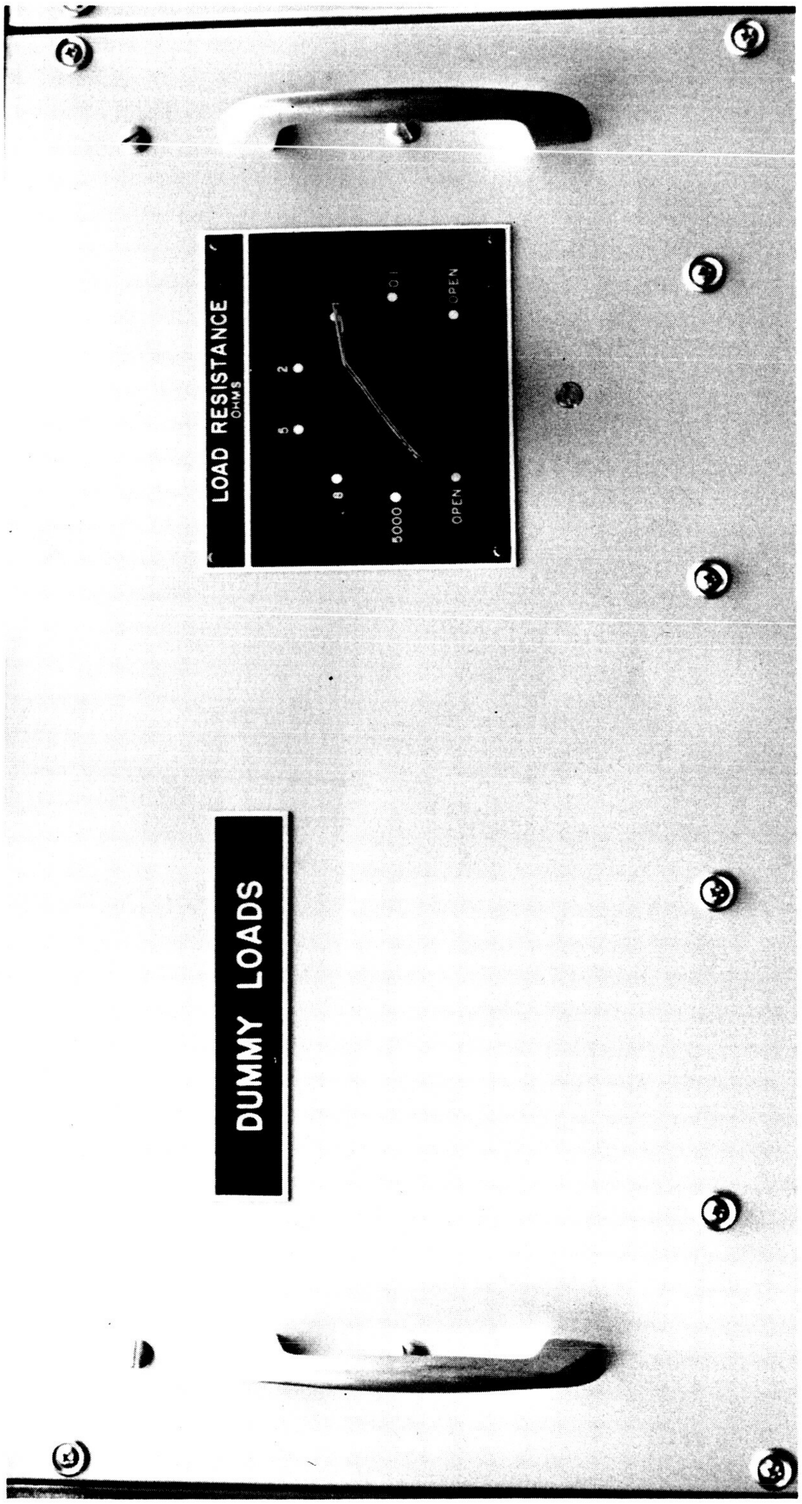
P-5 - CAPACITOR DISCHARGE GENERATOR AND PRECISION POWER SUPPLY



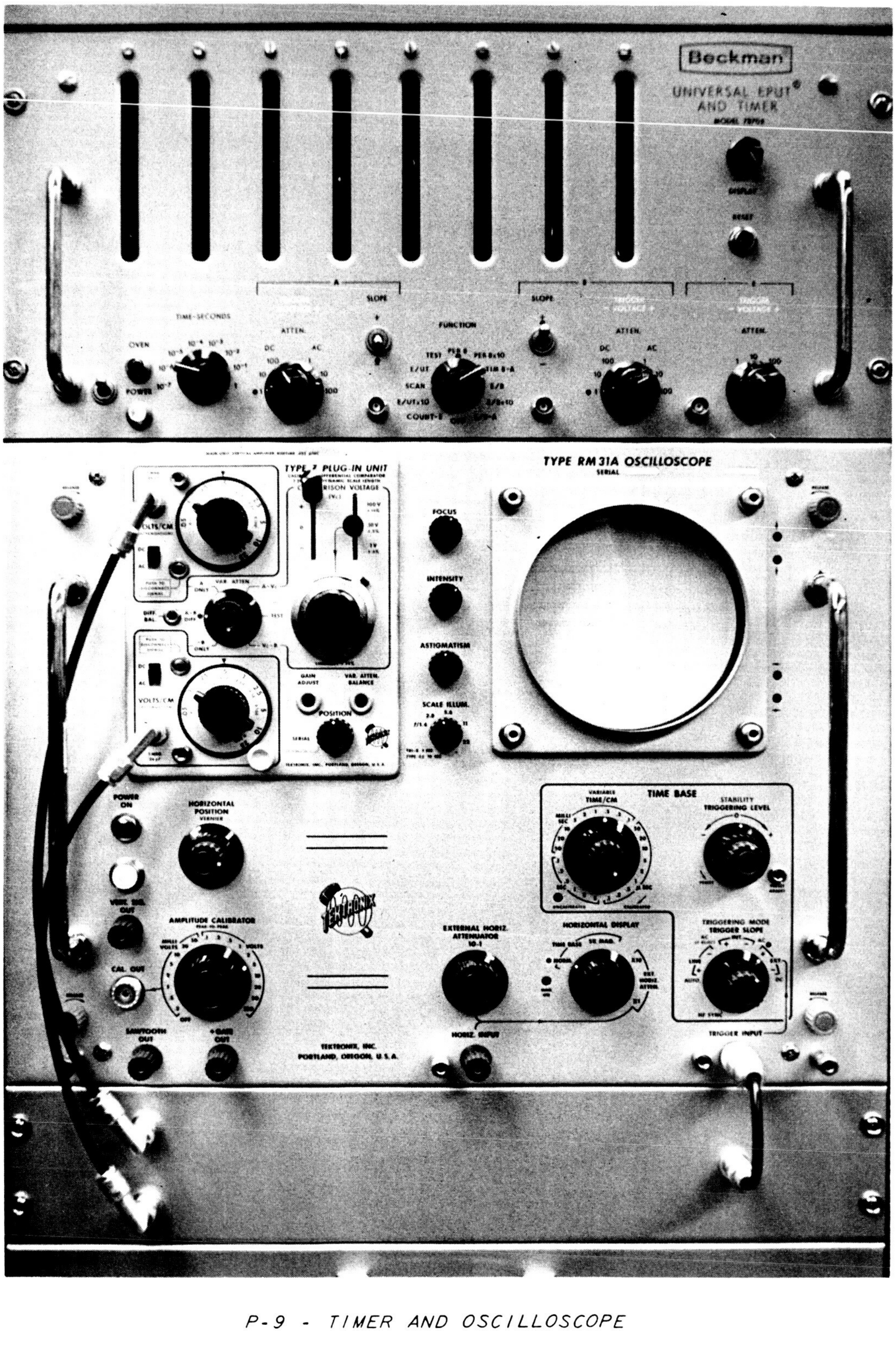
P-6 - EXPLODING BRIDGEWIRE GENERATOR



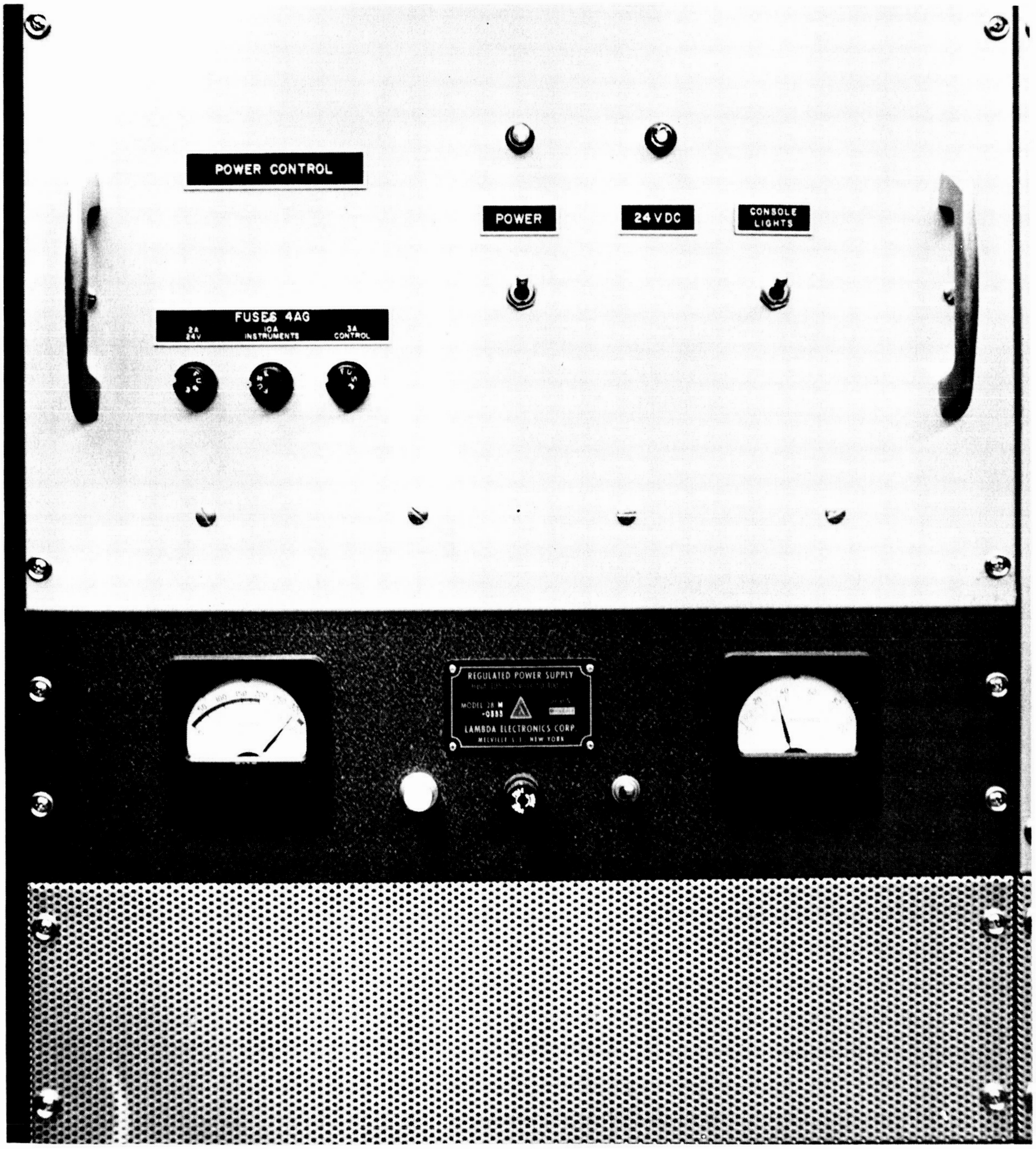
P-7 - DIGITAL VOLTMETER AND PREAMPLIFIER



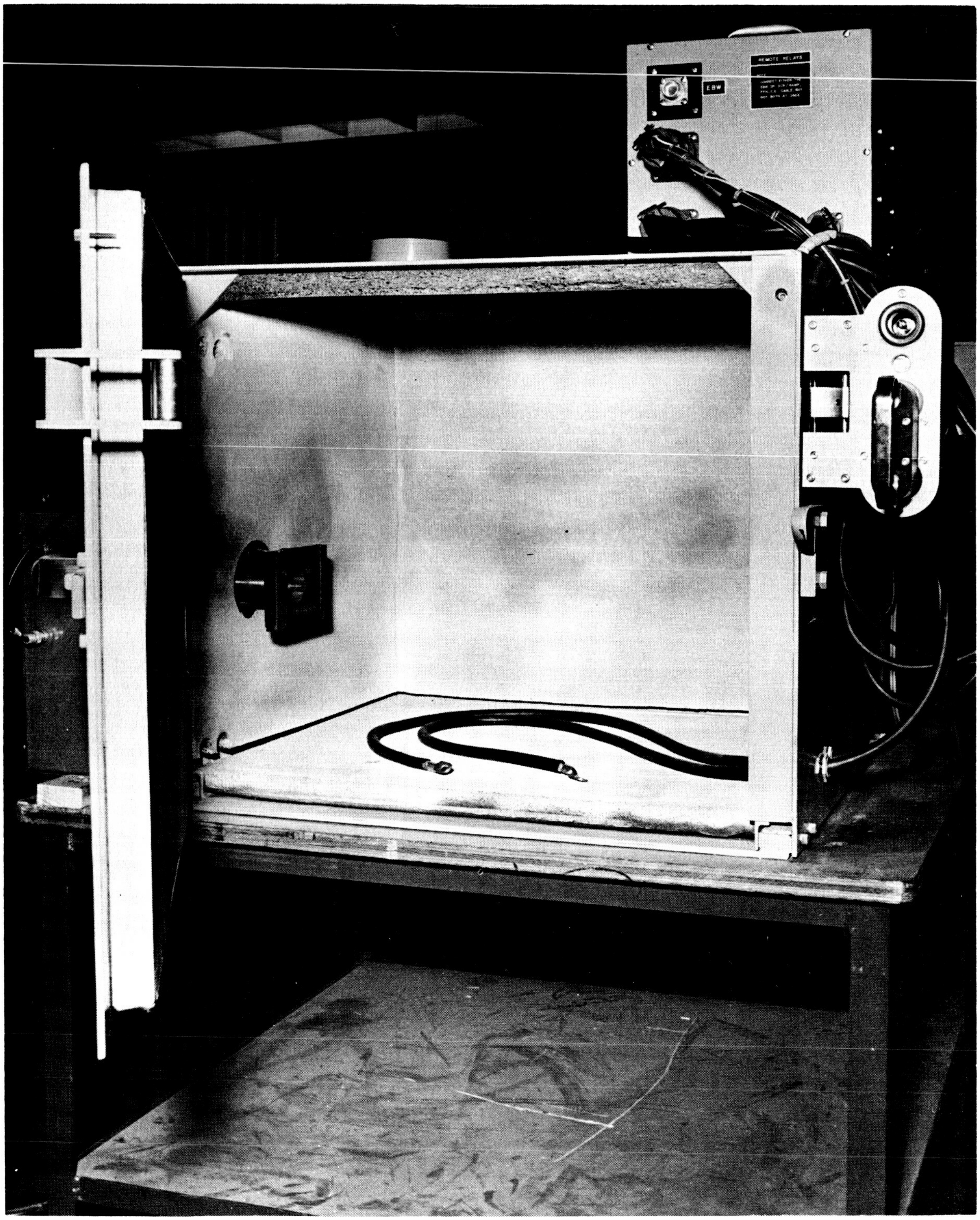
P-8 - DUMMY LOADS



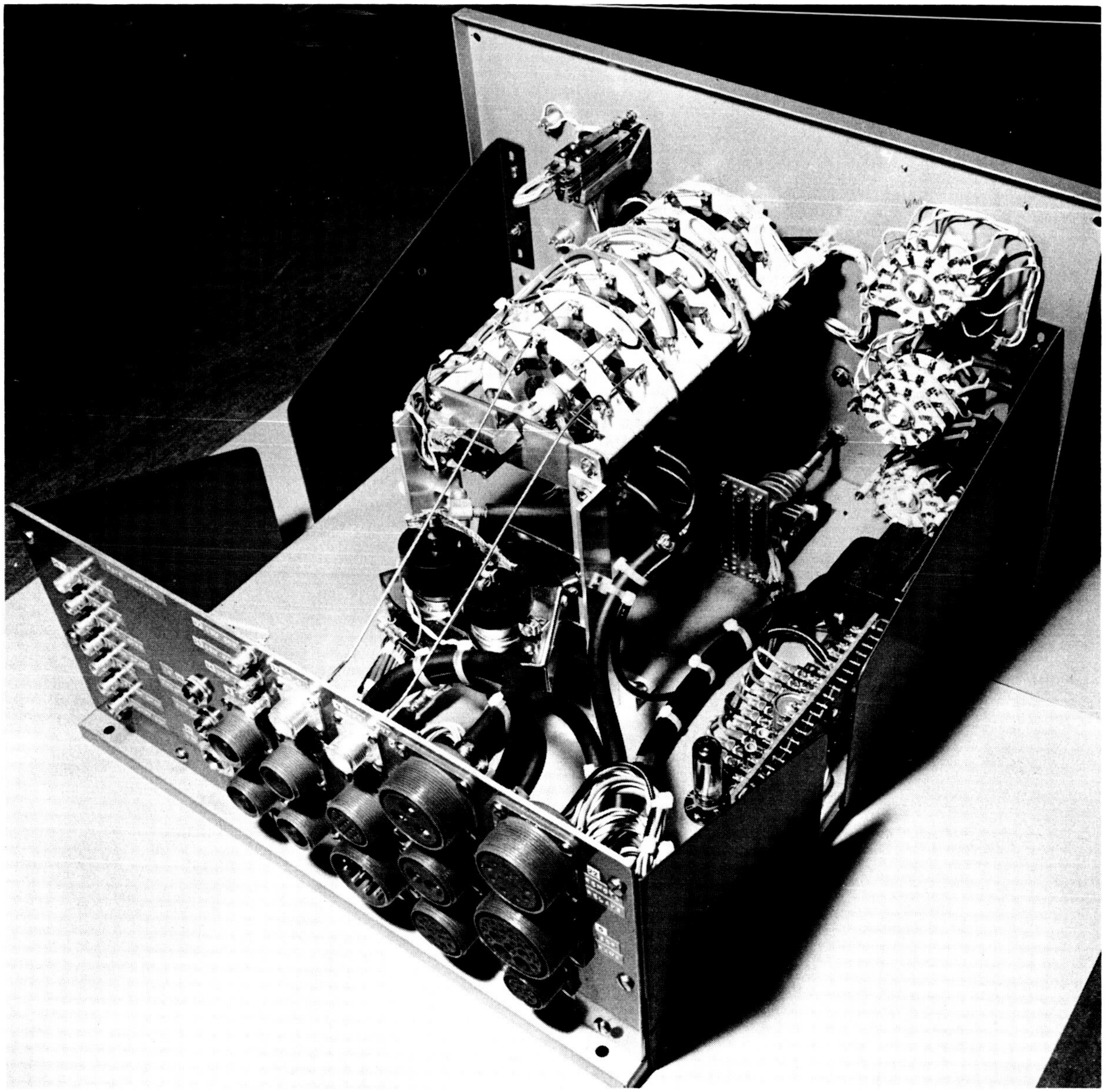
P-9 - TIMER AND OSCILLOSCOPE



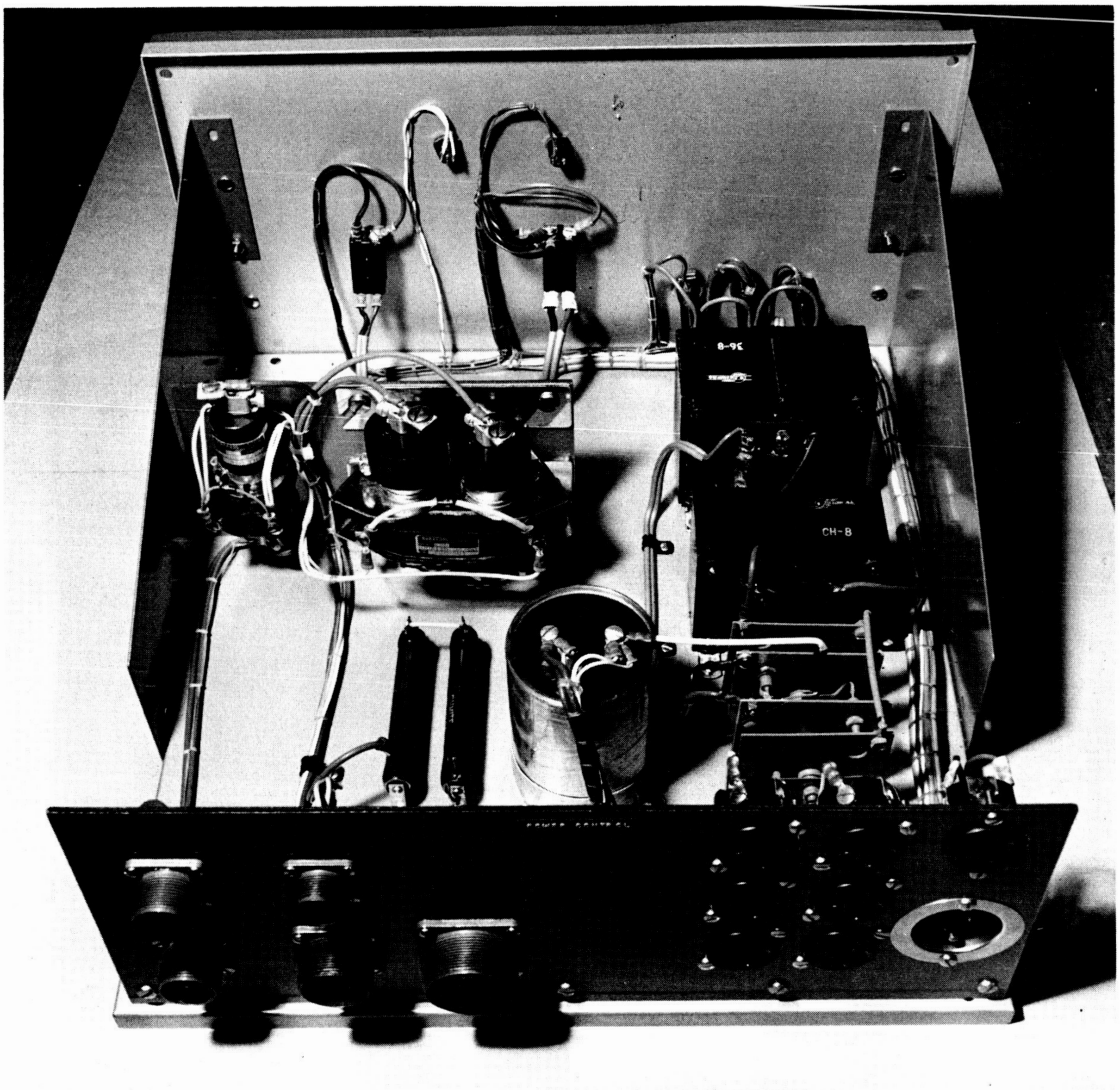
P-10 - POWER CONTROL PANEL



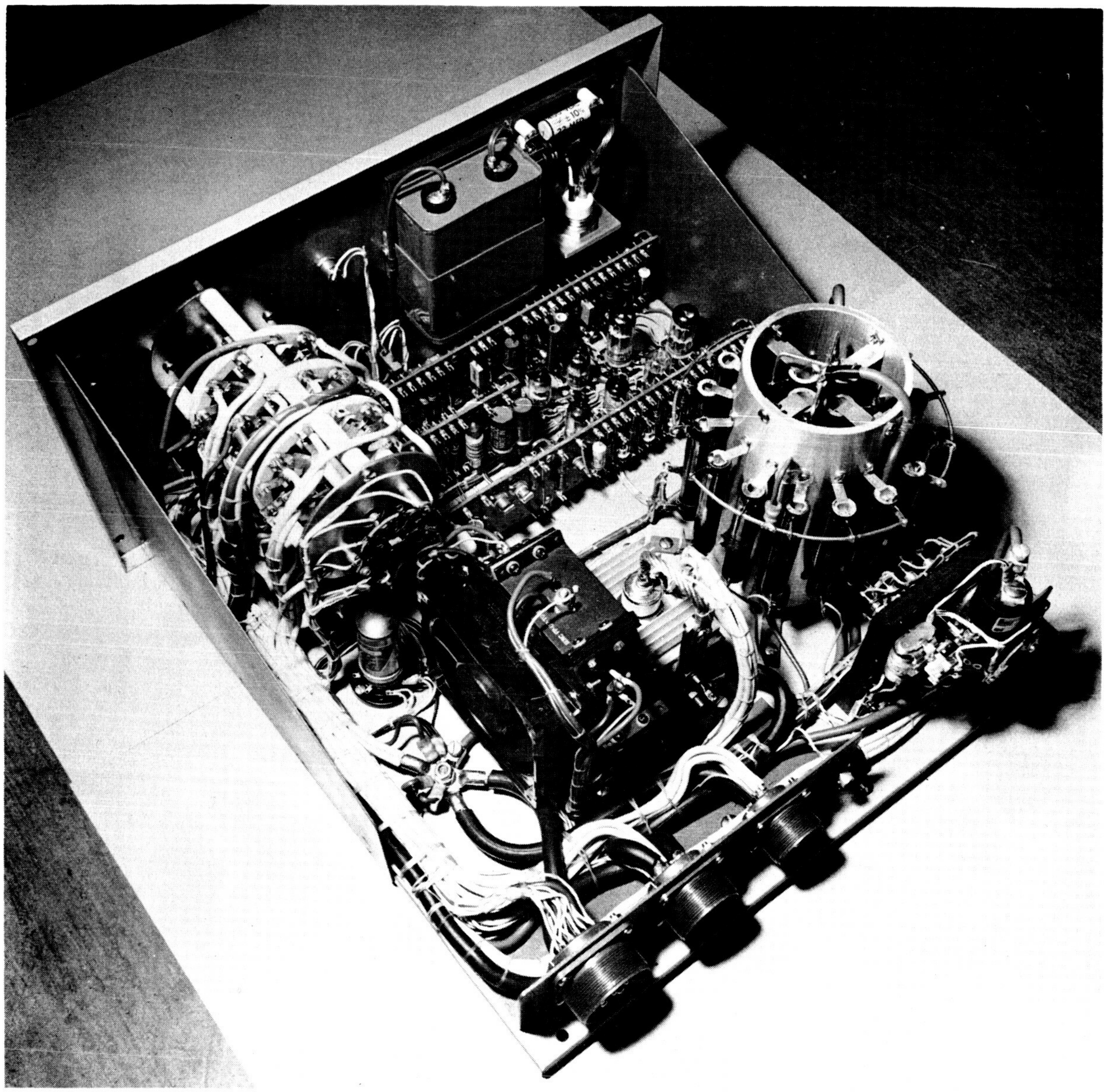
P-11 - FIRING CHAMBER - FLASH DETECTOR (LEFT) - SAFETY SWITCH (RIGHT) - REMOTE RELAYS (TOP)



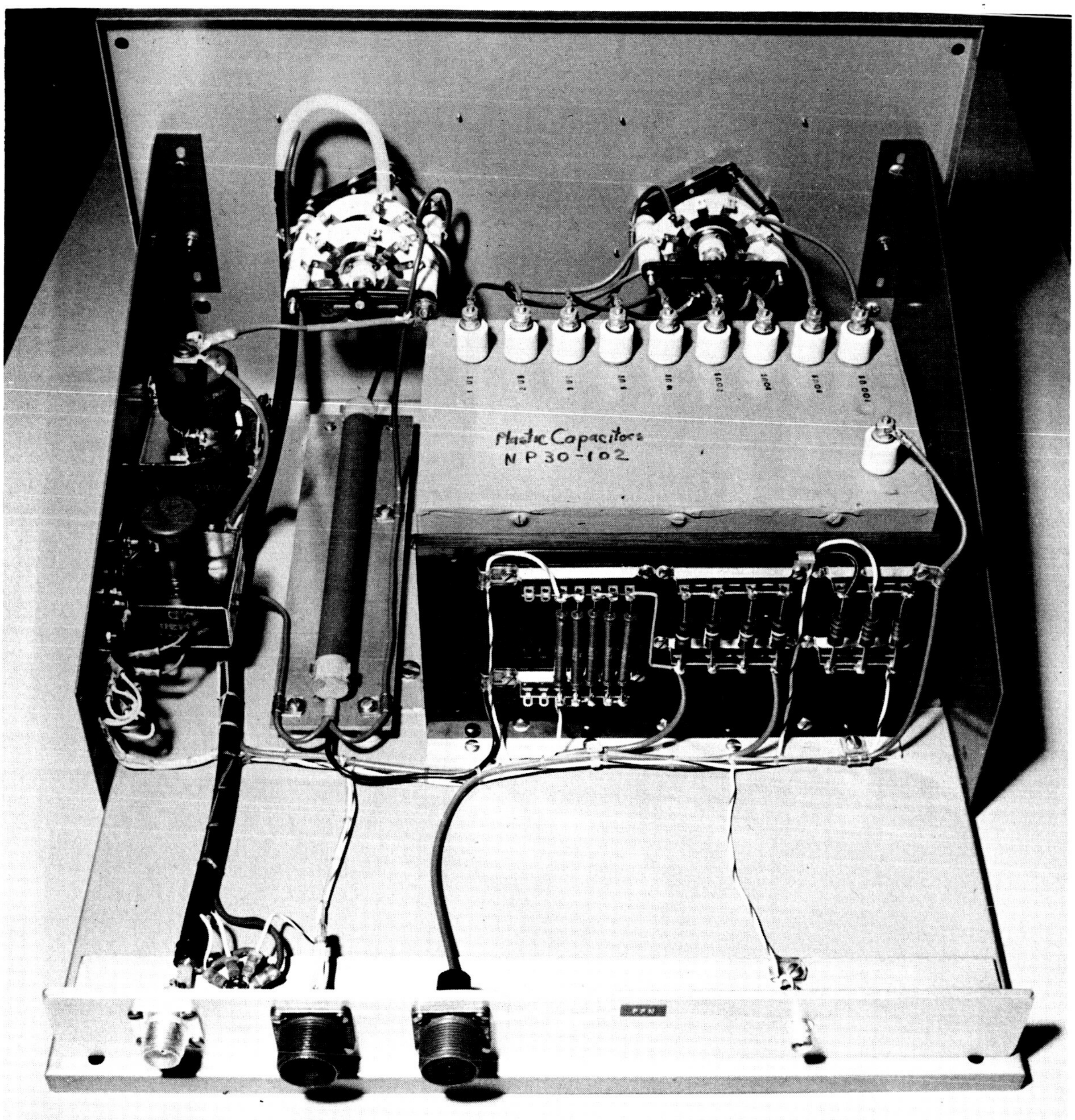
P-12 - MAIN CONTROL (REAR)



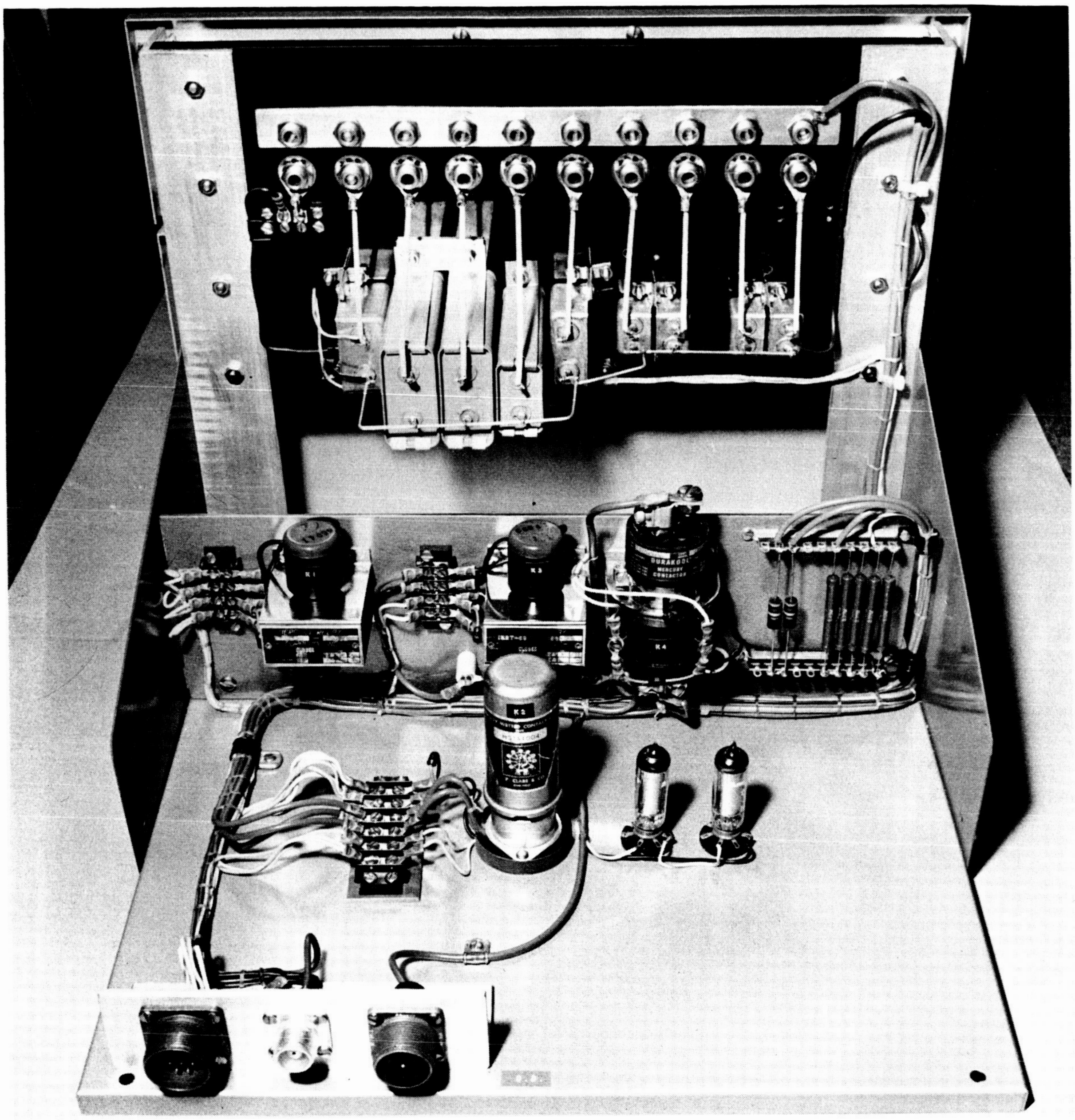
P-13 - POWER CONTROL (REAR)



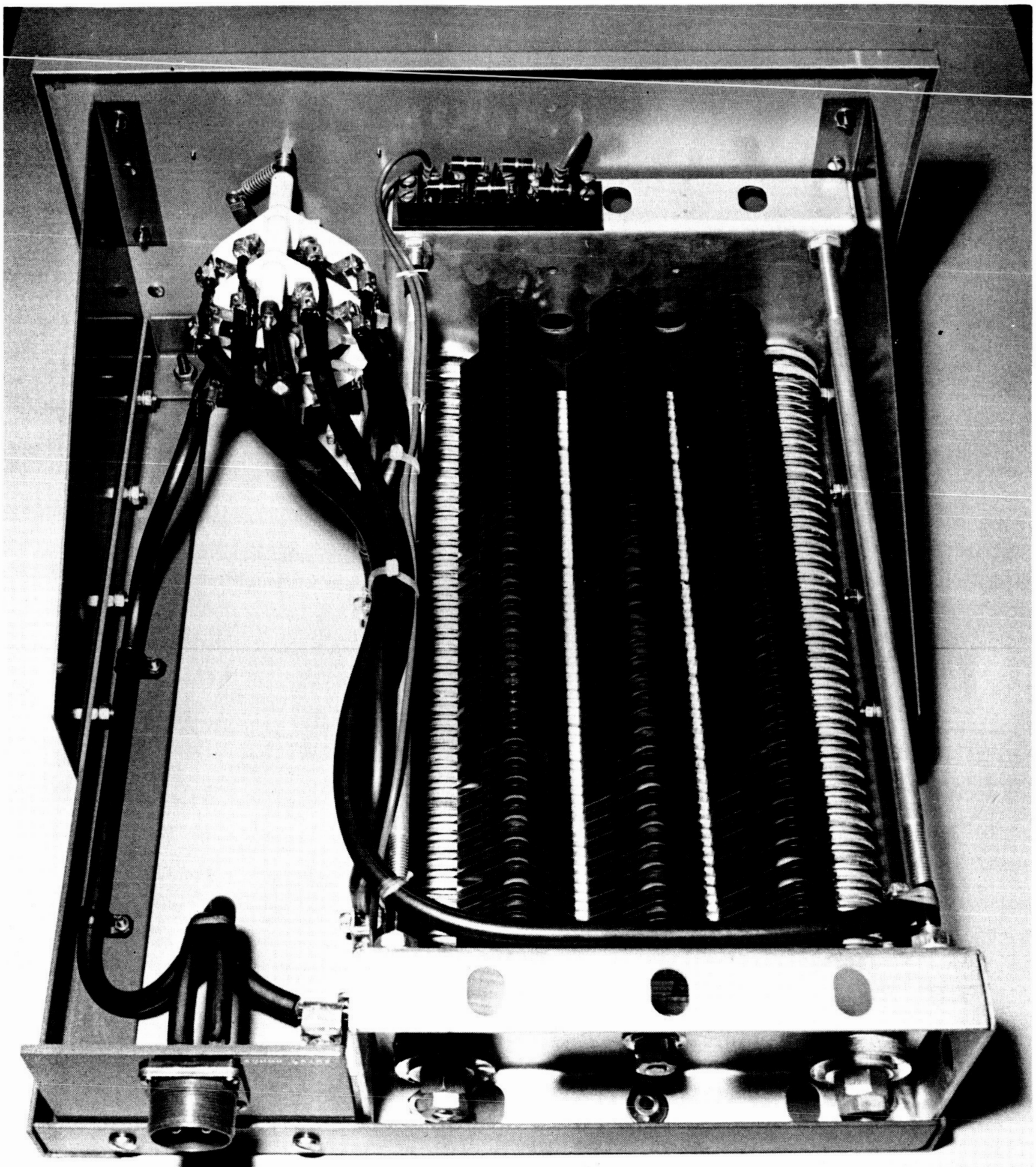
P-14 - SCR/RAMP GENERATOR (REAR)



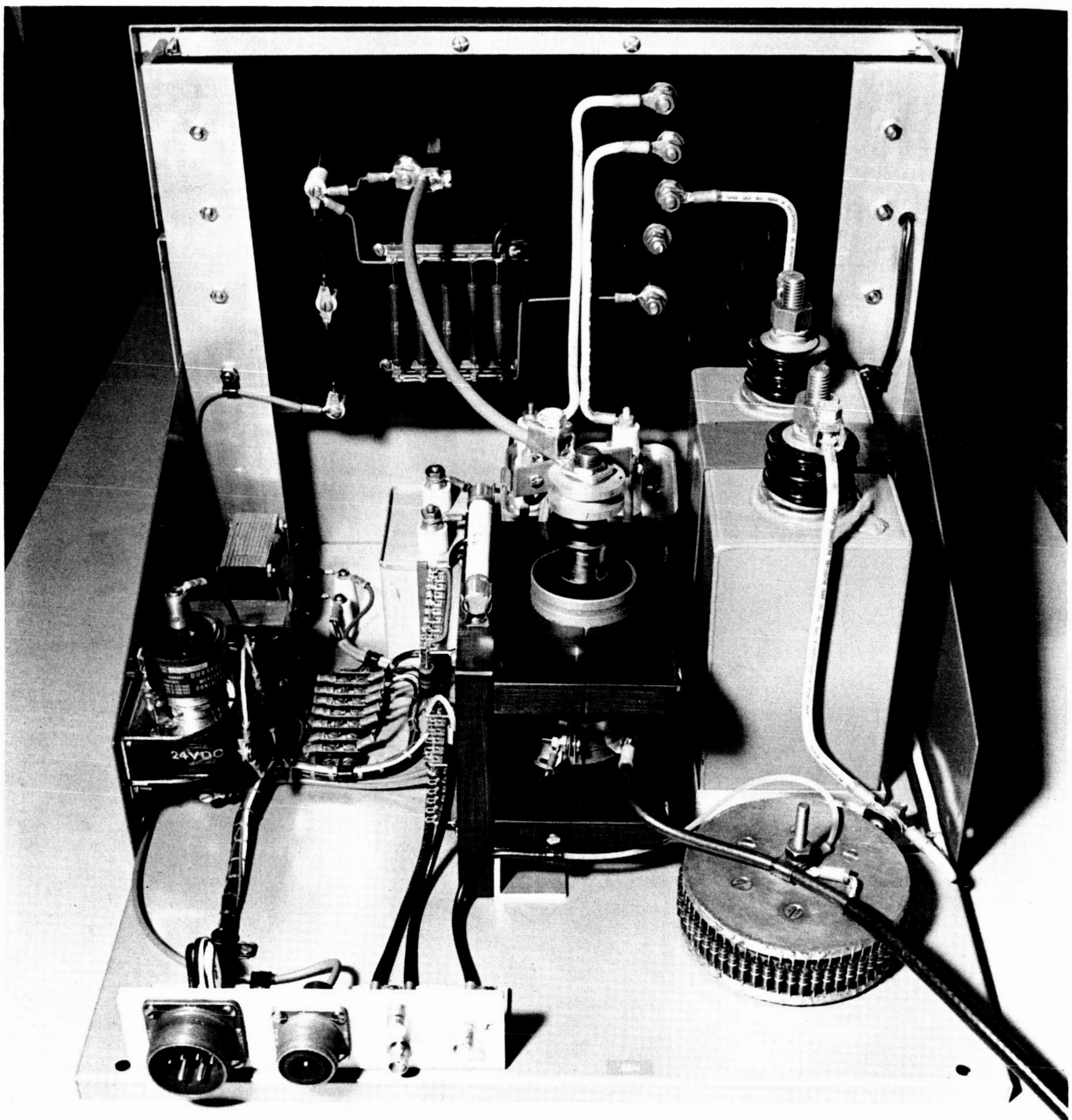
P-15 - PFN GENERATOR (REAR)



P-16 - CAPACITOR DISCHARGE GENERATOR (REAR)



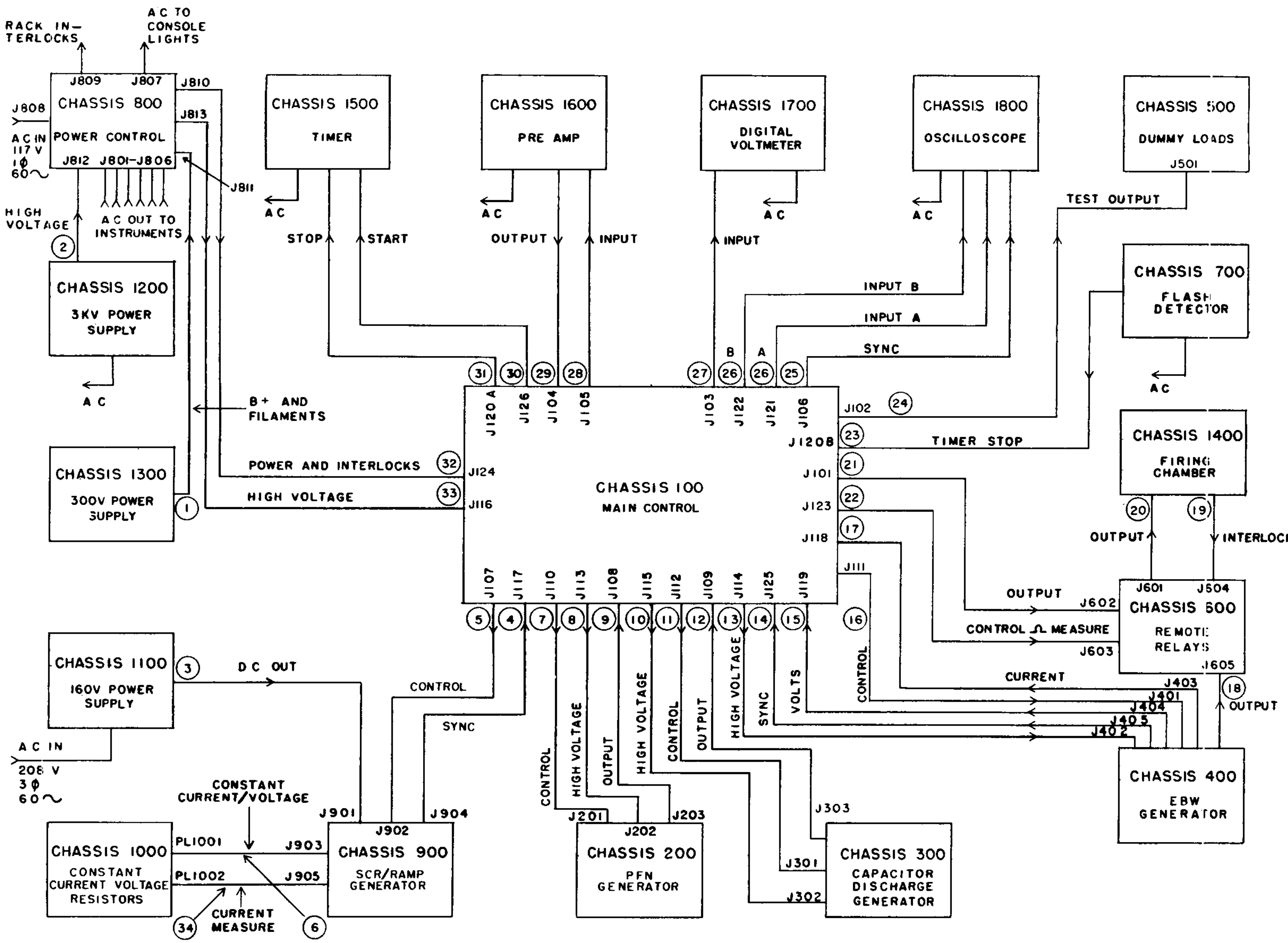
P-17 - DUMMY LOADS (REAR)



P-18 - EXPLODING BRIDGEWIRE GENERATOR (REAR)

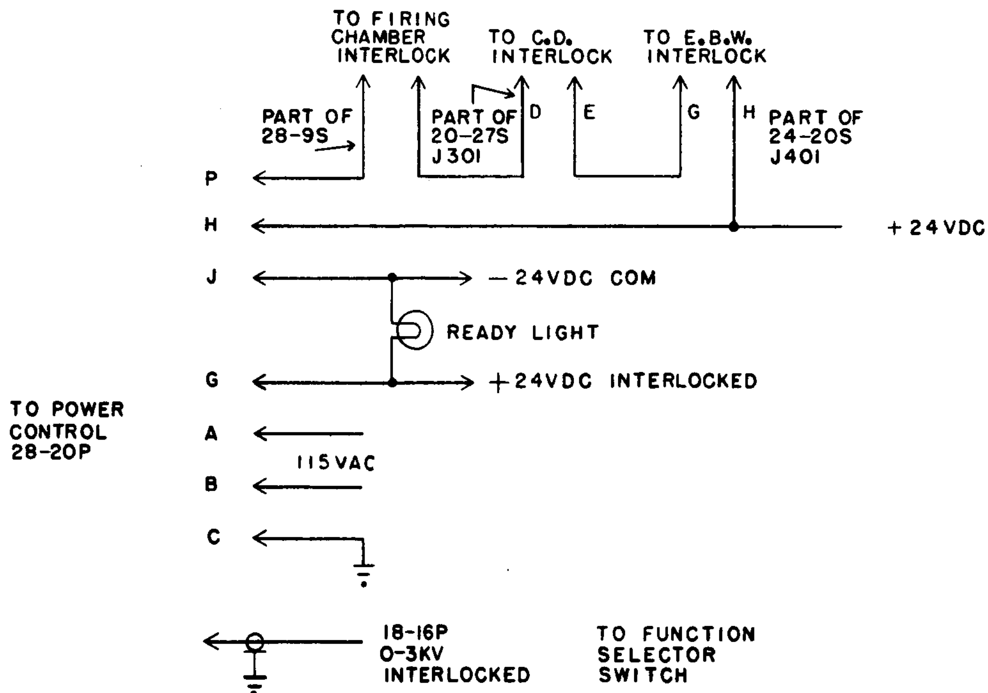
APPENDIX B

SCHEMATICS

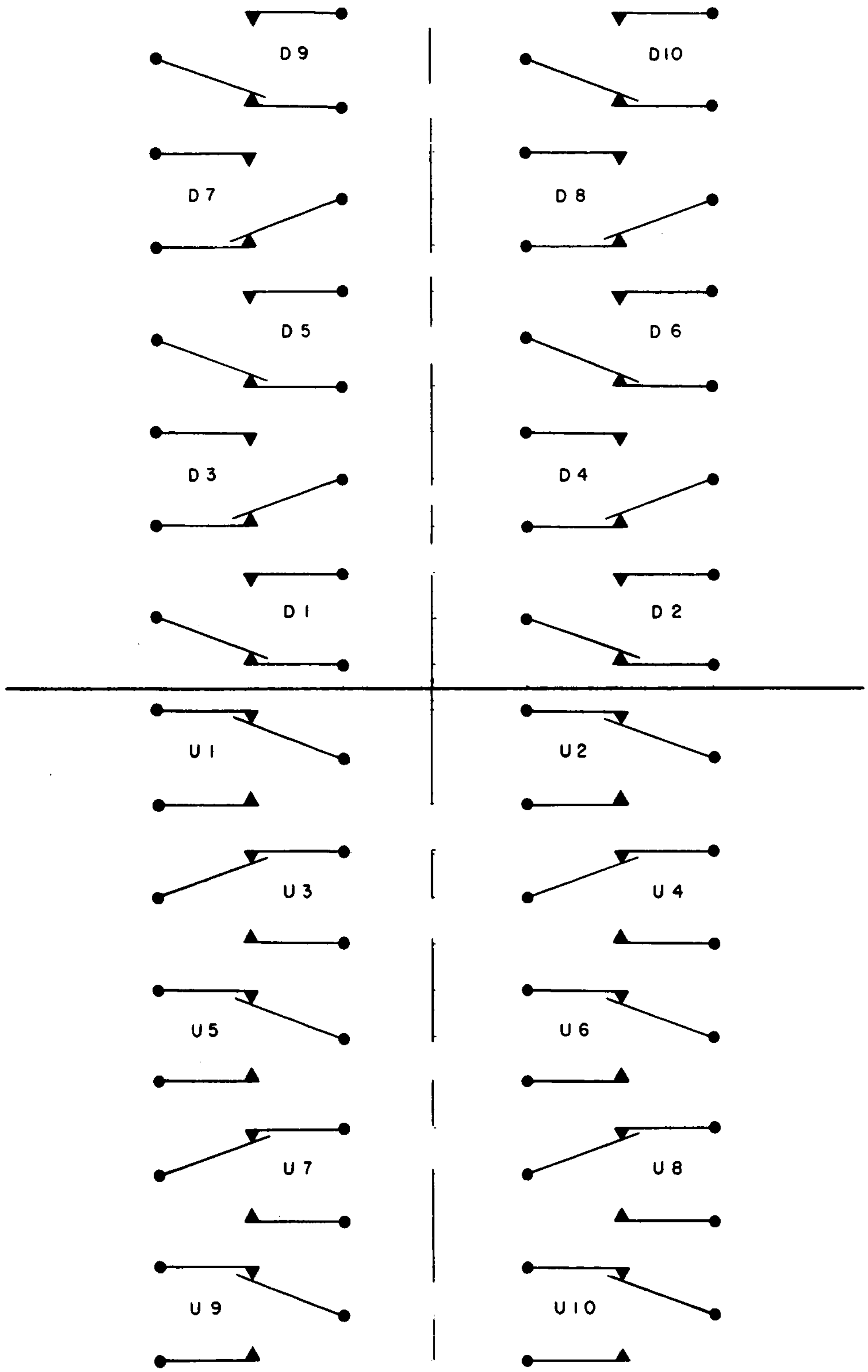


NOTE: CIRCLED NUMBERS ARE CABLE NUMBERS

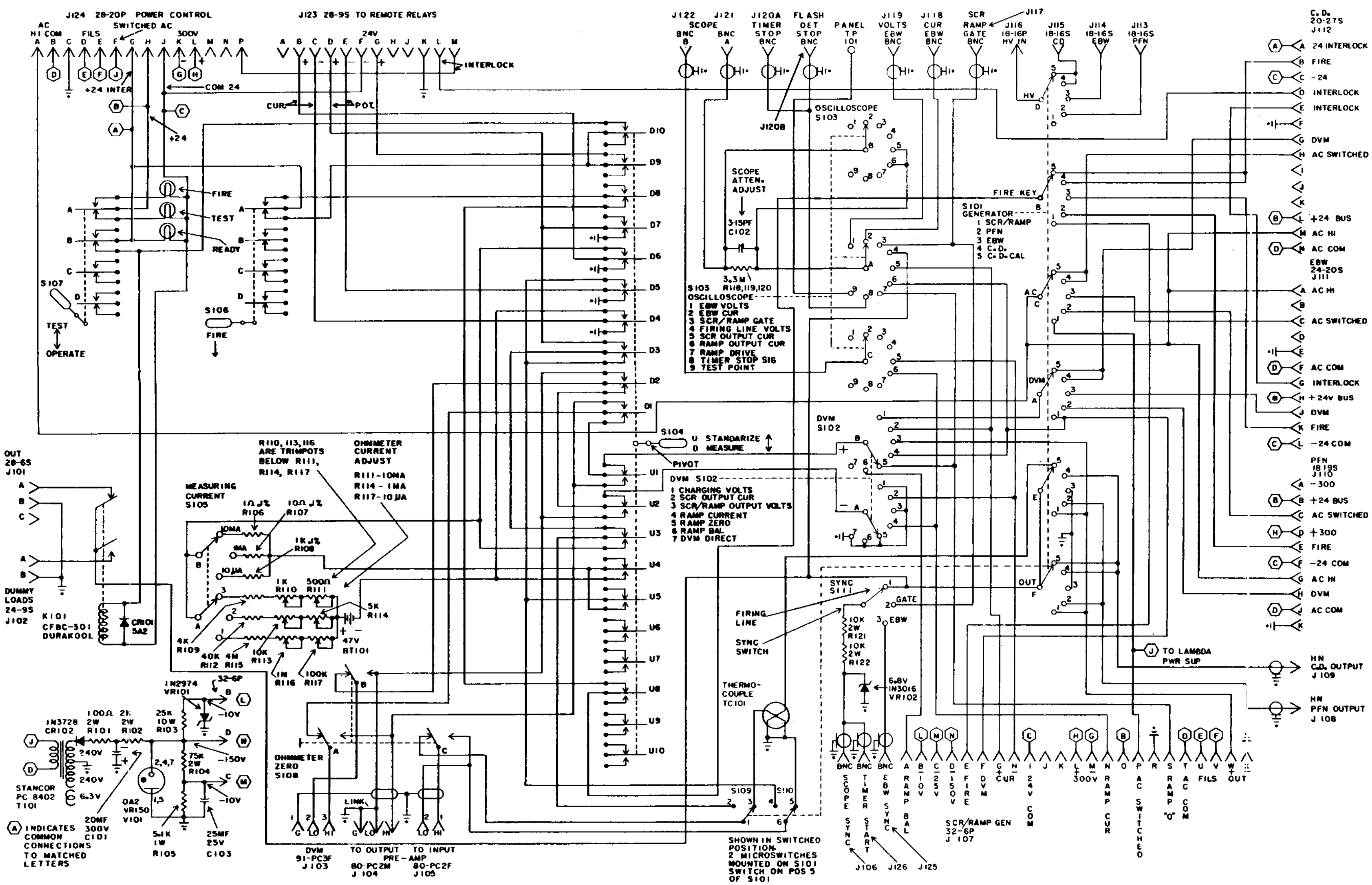
S-1 - INTERCONNECTION DIAGRAM



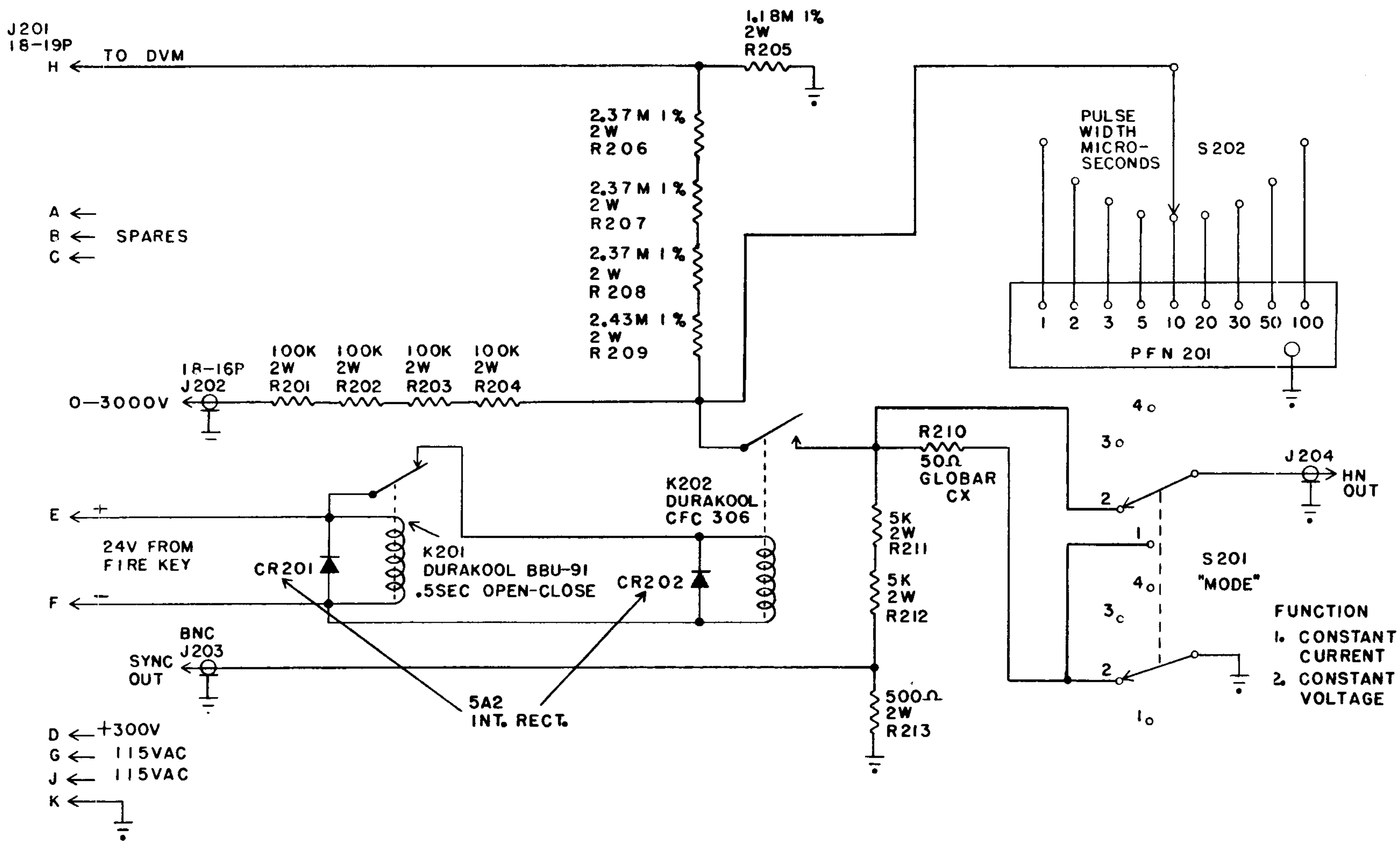
S-2 - DETAIL OF RELATIONSHIP OF INTERLOCK CONNECTIONS TO POWER PANEL



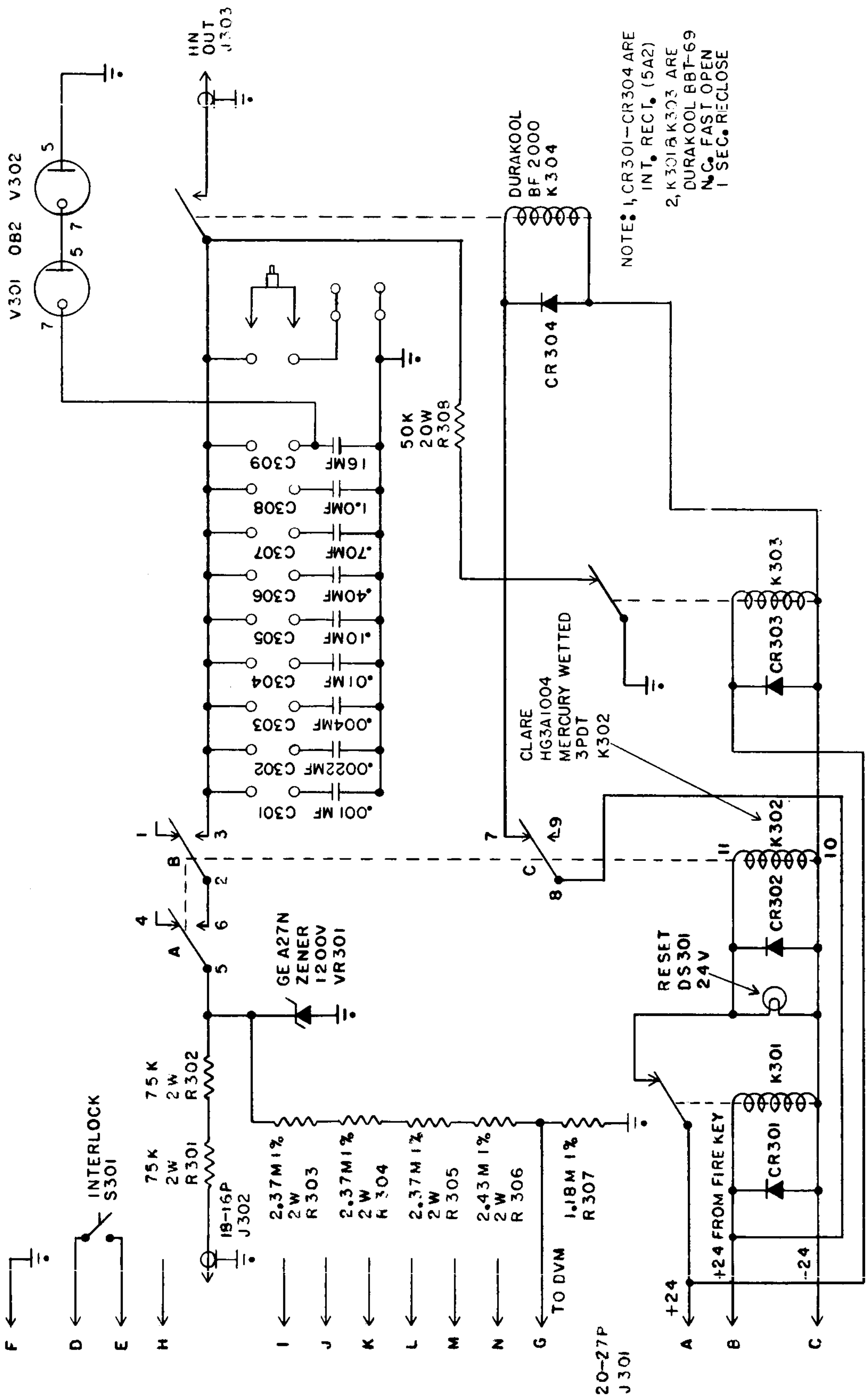
S-3 - OHMMETER KEY REAR VIEW SHOWING CONTACT ARRANGEMENT



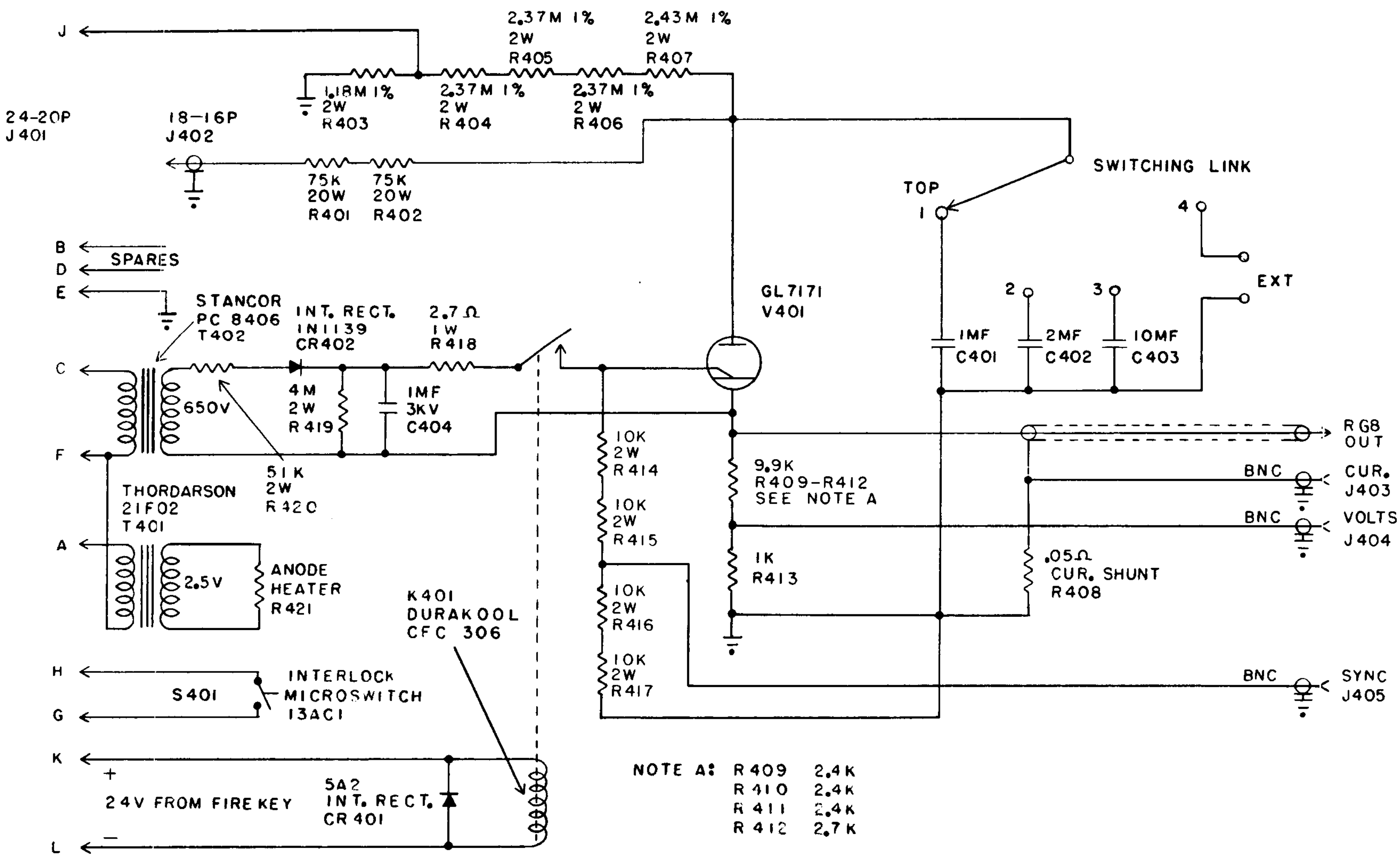
S-4 - MAIN CONTROL - CHASSIS 100



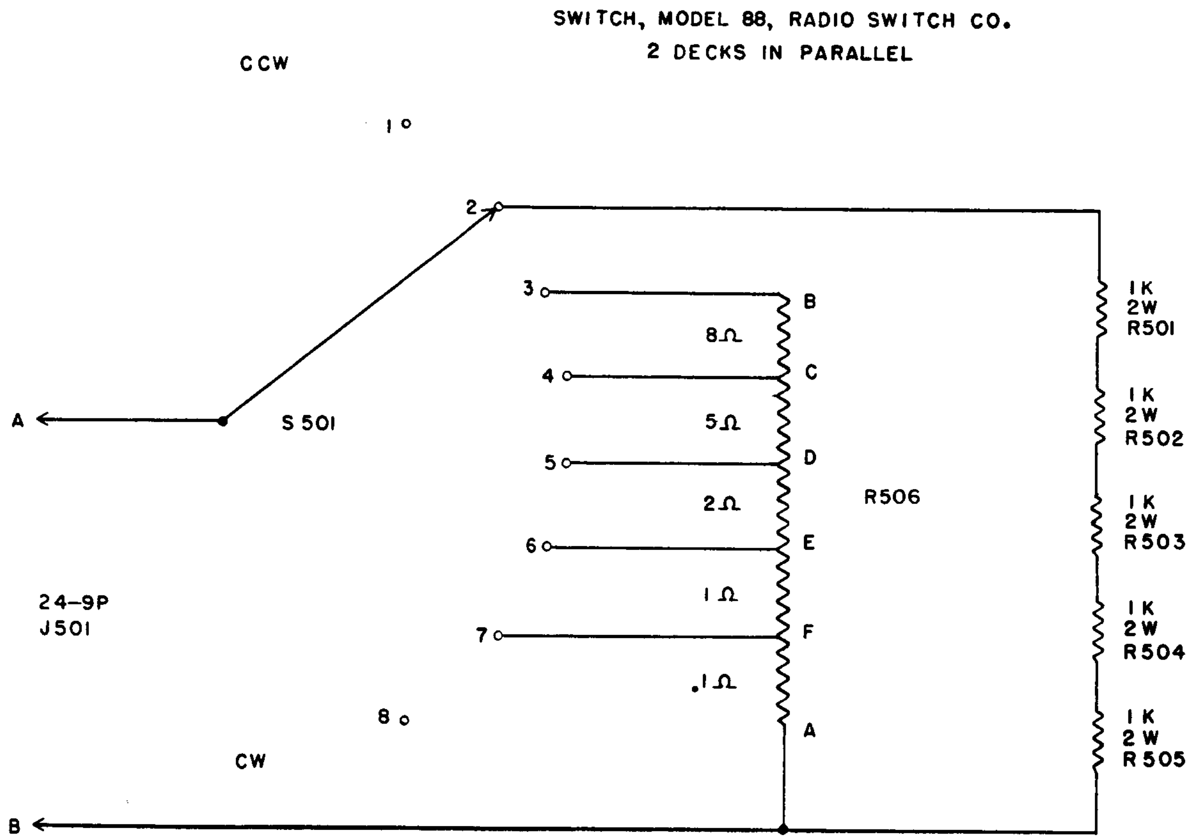
S-5 - PFN GENERATOR - CHASSIS 200



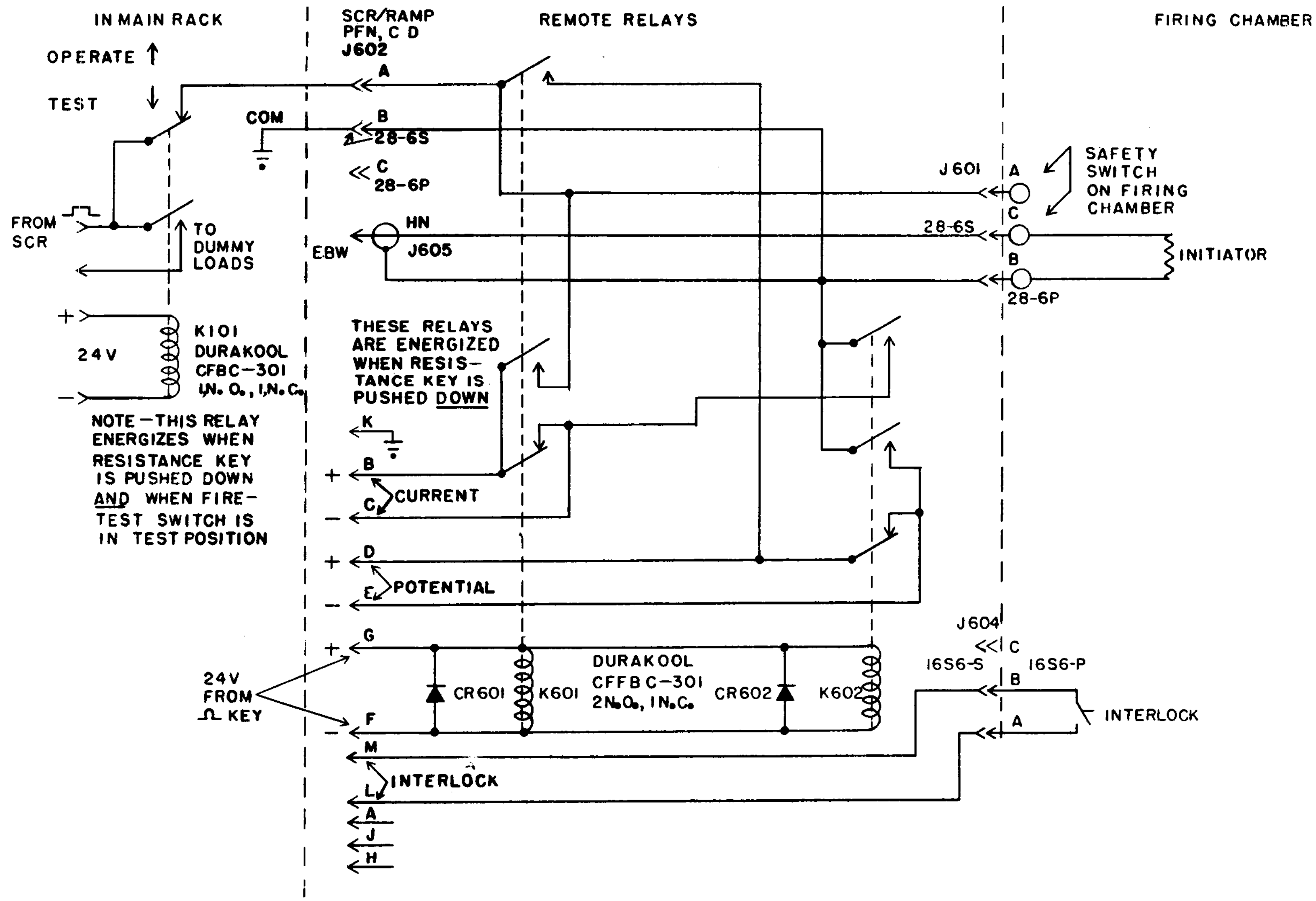
S-6 - CAP. DISCHARGE - CHASSIS 300



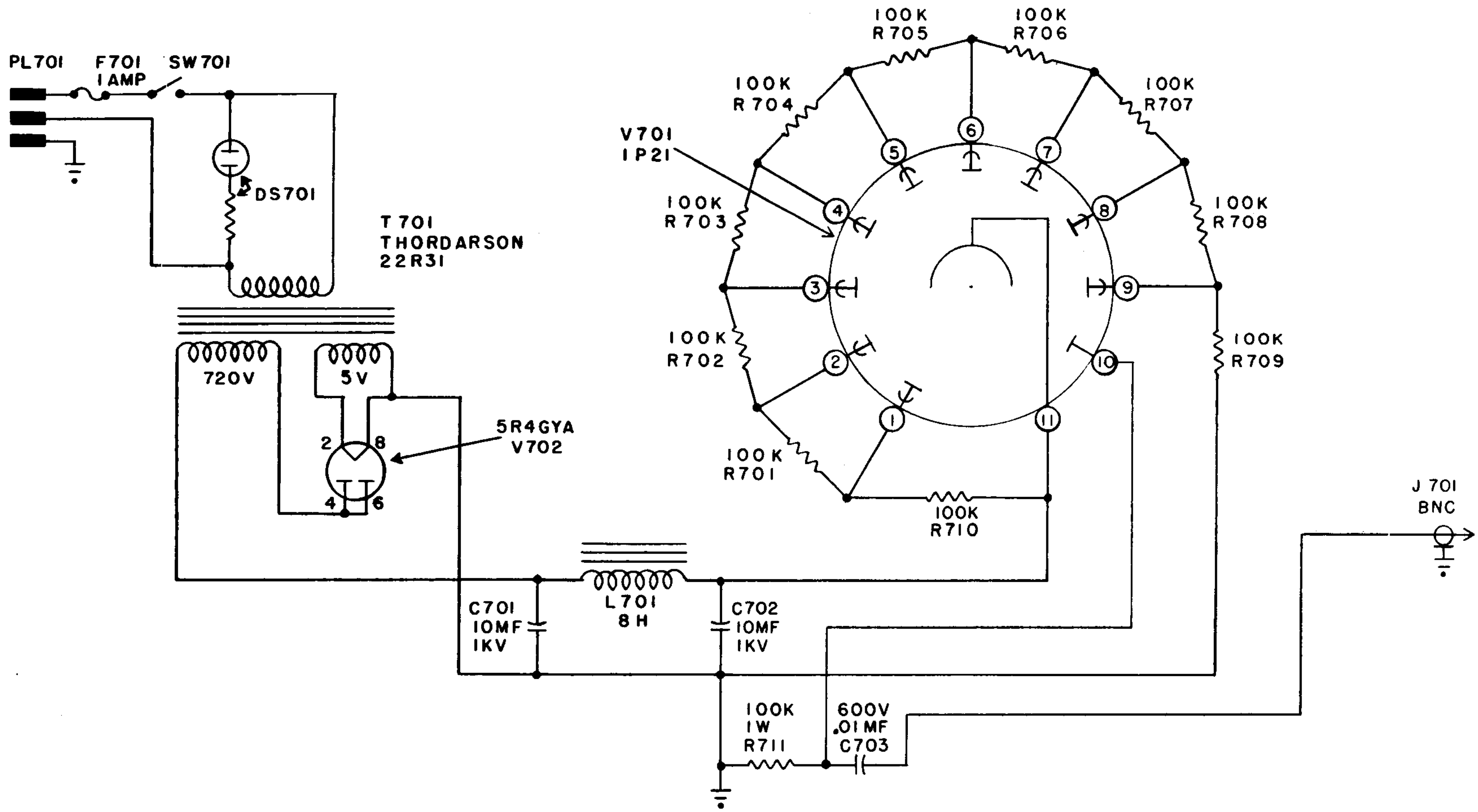
S-7 - EBW CHASSIS - CHASSIS 400



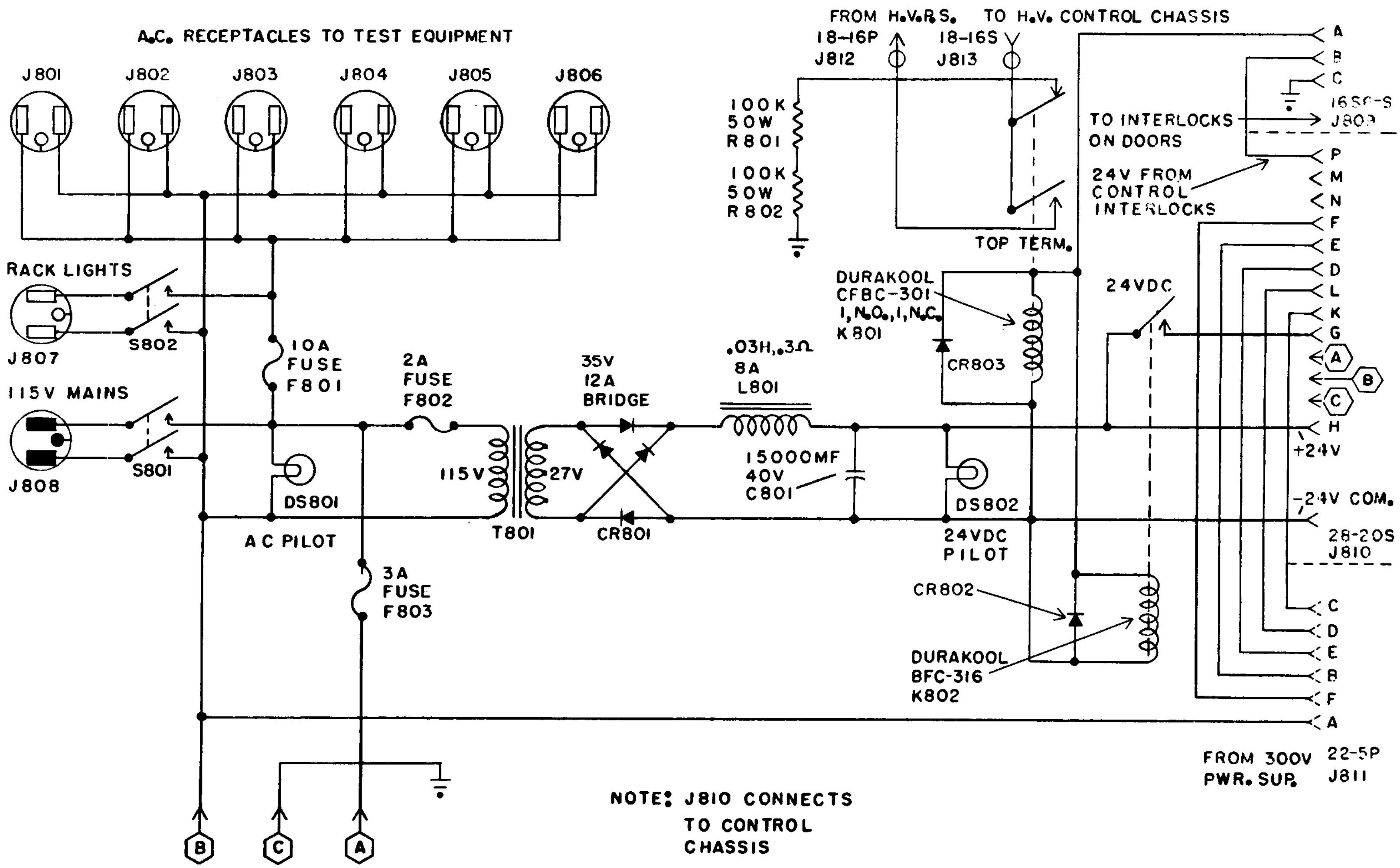
S-8 - DUMMY LOADS - CHASSIS 500



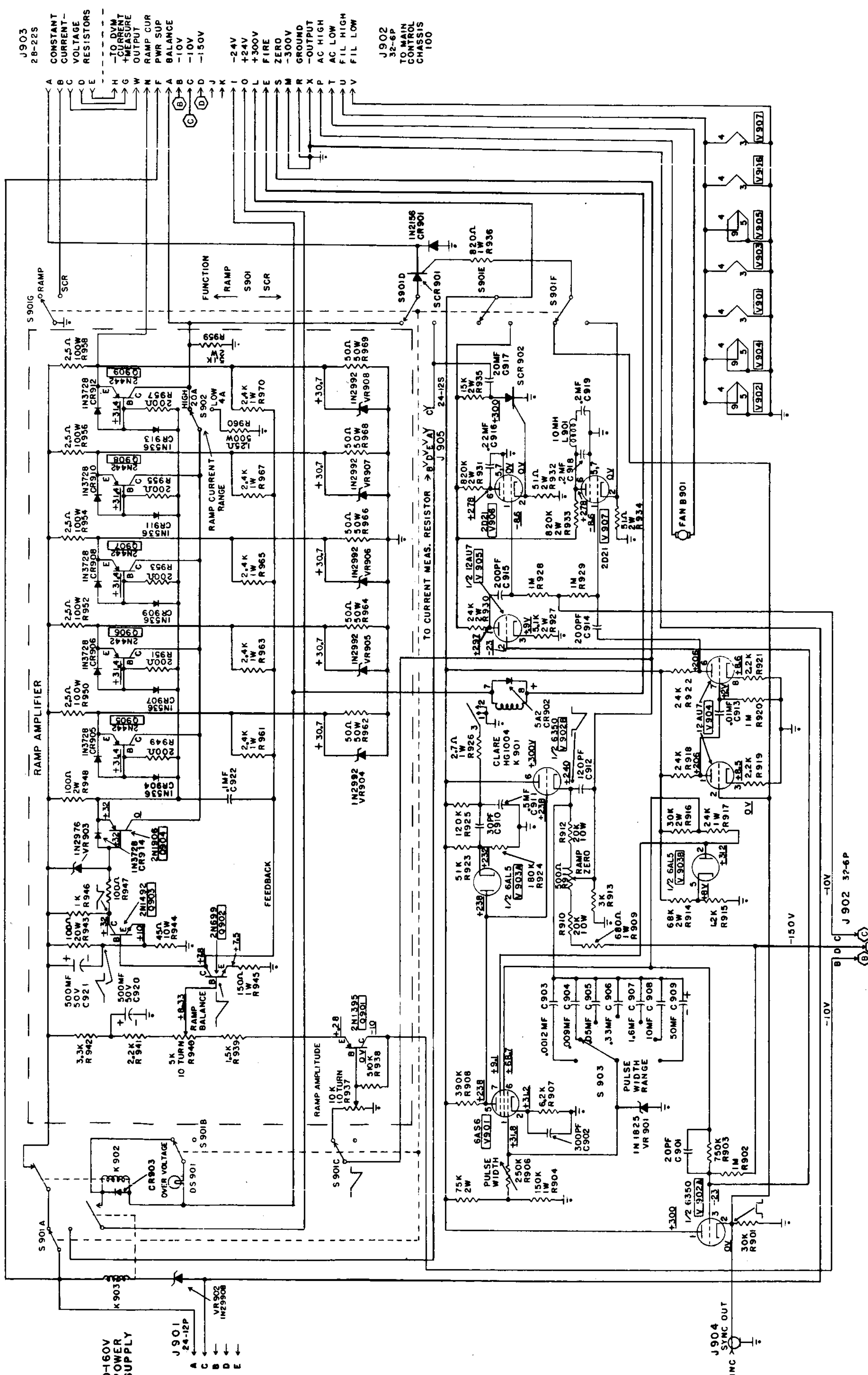
S-9 - REMOTE RELAYS FUNCTIONAL DIAGRAM SHOWING RELATED COMPONENTS - CHASSIS 600



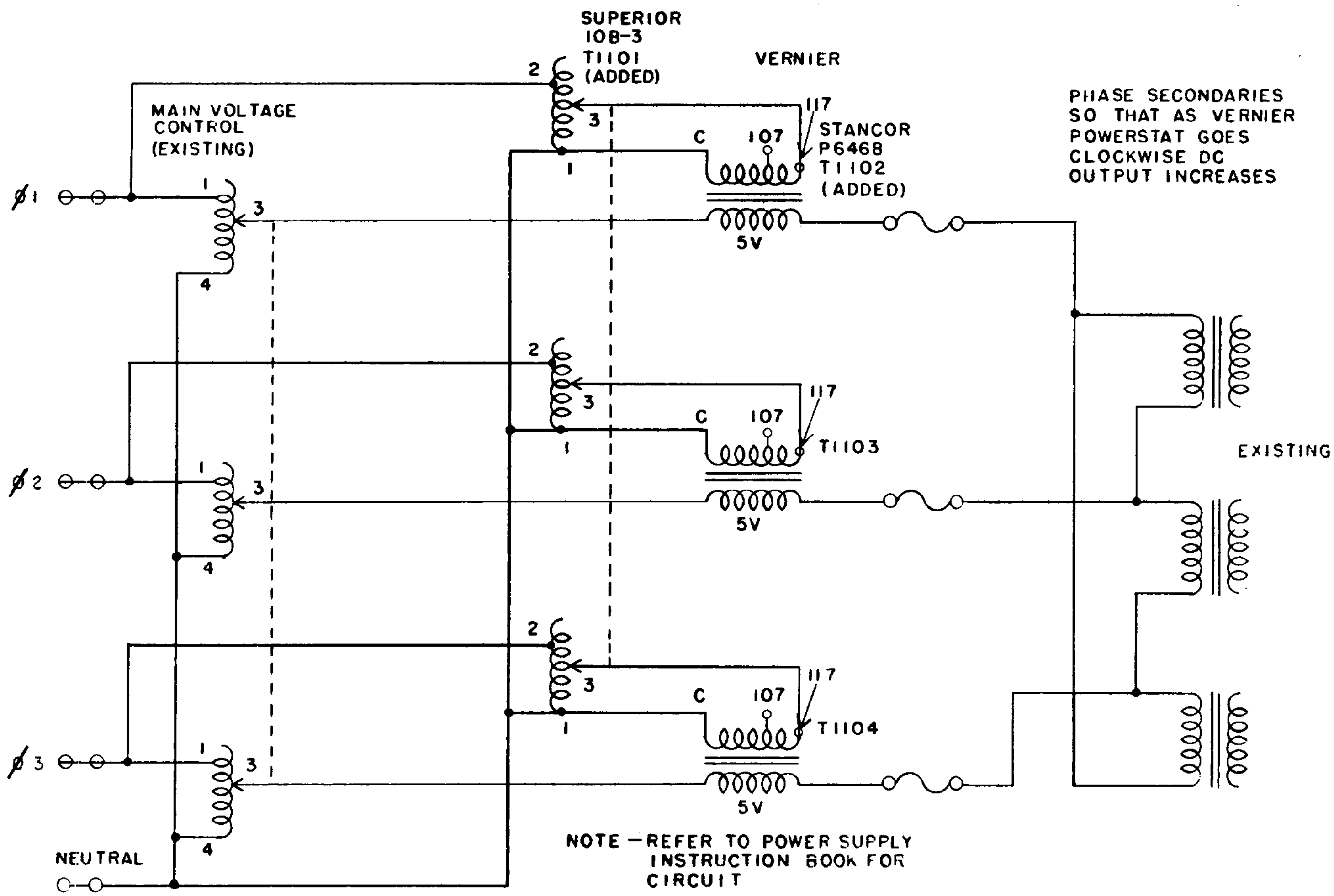
S-10 - FLASH DETECTOR - CHASSIS 700



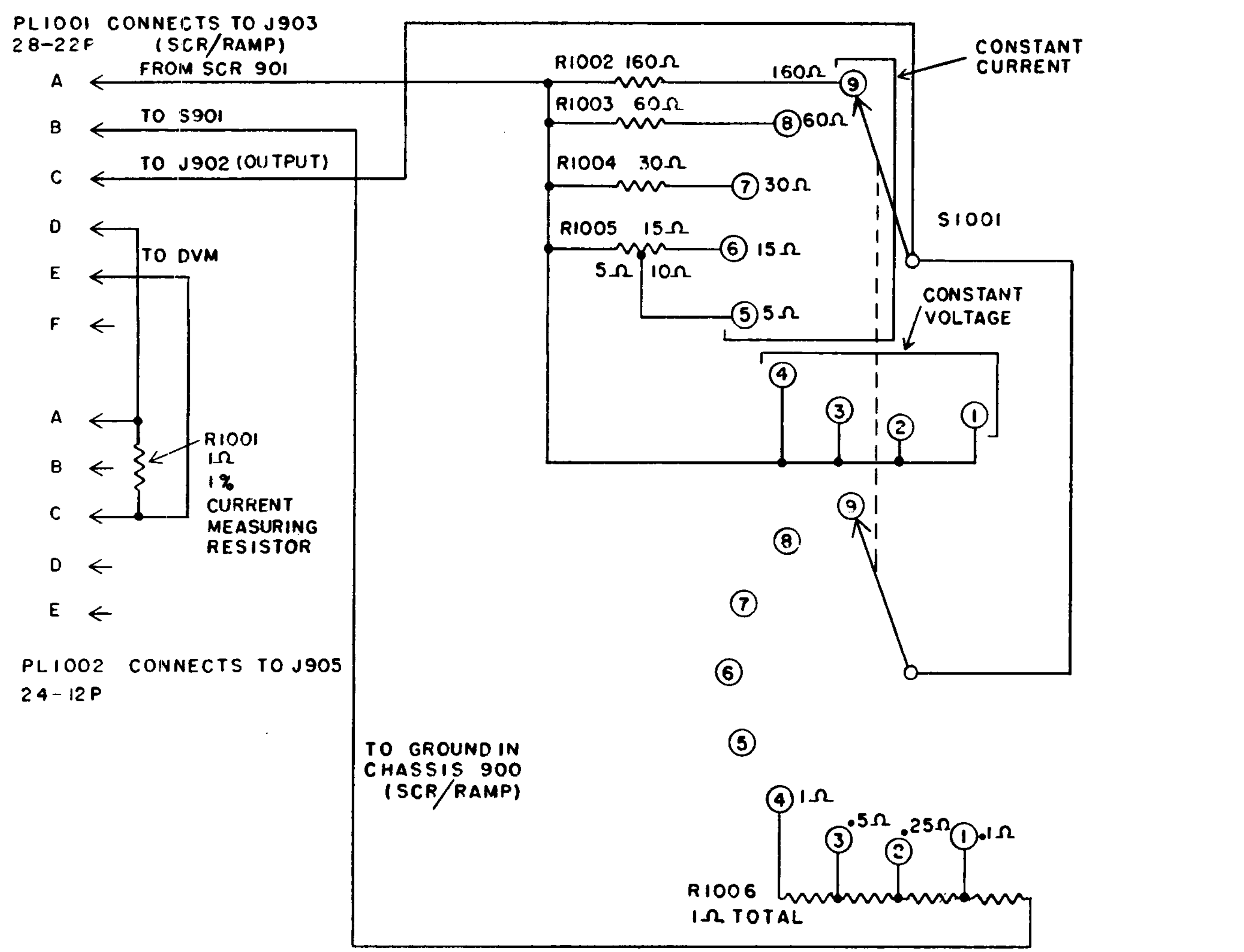
S-11 - POWER CONTROL AND INTERLOCK CHASSIS - CHASSIS 800



S-12 - SCR/RAMP GENERATOR - CHASSIS 900



S-13 - VOLTAGE VERNIER IN 160V, 5A POWER SUPPLY - CHASSIS 1100



SET TO ANY CONSTANT VOLTAGE POSITION FOR RAMP OPERATION

S1001 IS RADIO SWITCH CORPORATION MODEL 88
4 DECKS, 9 POSITION
2 DECKS PARALLEL FOR EACH SECTION

CIRCLED NUMBERS SHOW SWITCH POSITION

S-14 - SCR MODE SWITCHING CHASSIS 1100 (MOUNTED IN RACK)

APPENDIX C

PARTS LIST
CHASSIS #100 - MAIN CONTROL

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
J101	Connector, MS3102-28-6S					
J102	Connector, MS3102-24-9S					
J103	Connector, Microphone				Amphenol	91-PC3F
J104	Connector, Microphone				Amphenol	80-PC2M
J105	Connector, Microphone				Amphenol	80-PC2F
J106	Connector, BNC					UG-657/U
J107	Connector, MS3102-32-6P					
J108	Connector, HN					UG-496/U
J109	Connector, HN					UG-496/U
J110	Connector, MS3102-18-19S					
J111	Connector, MS3102-24-20S					
J112	Connector, MS3102-20-27S					
J113	Connector, MS3102-18-16S					
J114	Connector, MS3102-18-16S					
J115	Connector, MS3102-18-16S					
J116	Connector, MS3102-18-16P					
J117	Connector, BNC					UG-657/U
J118	Connector, BNC					UG-657/U
J119	Connector, BNC					UG-657/U
J120A	Connector, BNC					UG-657/U

CHASSIS #100 - MAIN CONTROL (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
J120B	Connector, BNC					UG-657/U
J121	Connector, BNC					UG-657/U
J122A	Connector, BNC					UG-657/U
J122B	Connector, BNC					UG-657/U
J123	Connector, MS3102-28-9S					
J124	Connector, MS3102-28-20P					
J125	Connector, BNC					UG-657/U
J126	Connector, BNC					UG-657/U
K101	Relay, Mercury Plunger 1NO, 1NC 24V Coil				Durakool	CFBC-301
CR101	Diode, Silicon				International Reet.	5A2
CR102	Diode, Silicon				Raytheon	LN3728
T101	Transformer, Power				Stancor	PC8402
TC101	Thermocouple, Vacuum	5 ma			Best Products, Ltd.	UH1
C101	Capacitor, Electrolytic	20µf	300v			
C102	Capacitor, Variable	3-15µµf	5kv			
C103	Capacitor, Electrolytic	25µf	25v			
V101	Diode, Regulator					OA2
VR101	Diode, Zener	10v	10w			1N2974
VR102	Diode, Zener	6.8v	10w			1N3016

CHASSIS #100 - MAIN CONTROL (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
BT101	Battery, Mercury	47v			Mallory	302465
R101	Resistor, Composition	100Ω	2w	5%	Ohmite	
R102	Resistor, Composition	2kΩ	2w	5%	Ohmite	
R103	Resistor, Composition	24kΩ	10w	10%		
R104	Resistor, Composition	75kΩ	2w	5%	Ohmite	
R105	Resistor, Composition	5.1kΩ	1w	5%	Ohmite	
R106	Resistor, Wirewound	1Ω		.1%	Consolidated Resistance Co.	P15RL-1Ω
R107	Resistor, Wirewound	10Ω		.1%		P15RL-10Ω
R108	Resistor, Wirewound	1kΩ		.1%		P15RL-1000Ω
R109	Resistor, Deposited Carbon	4kΩ	1w	.1%		
R110	Resistor, Variable	1kΩ	$\frac{1}{4}$w	10%	Bourns	273-1-102M
R111	Resistor, 10 Turn Variable	500Ω	2w	3%	Bourns	3500S-1-501
R112	Resistor, Deposited Carbon	40kΩ	1w	1%	Bourns	
R113	Resistor, Variable	10kΩ	$\frac{1}{4}$w	10%	Bourns	273-1-103M
R114	Resistor, 10 Turn Variable	5kΩ	2w	3%	Bourns	3500S-1-502
R115	Resistor, Deposited Carbon	4 megΩ	1w	1%		
R116	Resistor, Variable	1 megΩ	$\frac{1}{4}$w	10%	Bourns	274-1-105M

CHASSIS #100 - MAIN CONTROL (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R117	Resistor, 10 Turn Variable	100kΩ	2w	3%	Bourns	3500S-1-104
R118	Resistor, Deposited Carbon	3 megΩ	2w	1%		
R119	Resistor, Deposited Carbon	3 megΩ	2w	1%		
R120	Resistor, Deposited Carbon	3 megΩ	2w	1%		
R121	Resistor, Composition	10kΩ	2w	5%	Ohmite	
R122	Resistor, Composition	10kΩ	2w	5%		
S101	Switch, Rotary Switch, 6 Decks, A Rotor Switch, 36°				Radio Switch Co	Model 88
S102	Switch, Rotary 2 Decks, 30°Rotor				Co	Model 80
S103	Switch, Rotary 3 Decks, 30° Rotary				Co	Model 80
S104	Switch, Lever 2 Position Non-locking 10 Form C Contacts each Pos.				Mossman	Series 4203
S105	Switch, Rotary 2 pole 3 pos.				Shallcross	2H56A8-1
S106	Switch, Lever Non-Locking 4 Form C Contacts				Mossman	Series 4203

CHASSIS #100 - MAIN CONTROL (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
S107	Switch, Lever 2 Position 2 Form C Contacts each Position				Mossman	Series 4202
S108	Switch, Pushbutton 3 Pole Double Throw					
S109	Switch, Micro				Micro Switch	V3-1
S110	Mounted on S101					

CHASSIS #200 - PFN GENERATOR

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
J201	Connector, MS3102-18-19P					
J202	Connector, MS3102-18-16P					
J203	Connector, BNC					UG-657/U
J204	Connector, HN					UG-496/U
S201	Switch Rotary 2 Decks, E Rotor, 30°				Radio Switch Company	Model 86
K201	Relay, Mercury Plunger NC, ½ sec open and close, 24v Coil				Durakool	BBV-91
K202	Relay, Mercury Plunger No, 24v Coil				Durakool	CFC 306
CR201 CR202	Diode, Silicon				International Rectifier	
PFN201	Pulse Forming Network, Special				Plastic Capacitor	NP30-102
R201 R202 R203 R204 R205	Resistor, Composition	100kΩ	2w	5%	Ohmite	
R205	Resistor, Deposited Carbon	1.18 megΩ	2w	1%		
R206	Resistor, Deposited Carbon	2.43 megΩ	2w	1%		

CHASSIS #200 - PFN GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R207	Resistor, Deposited	2.37 megΩ	2w	1%		
R208						
R209						
R210	Resistor, Non-Inductive	50Ω			Carborundum Co.	Glowbar CX
R211	Resistor, Composition	5kΩ	2w	5%	Ohmite	
R212						
R213	Resistor, Composition	500Ω	2w	5%	Ohmite	

CHASSIS #300 - CAPACITOR DISCHARGE

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
J301	Connector, MS-3102-20-27P					
J302	Connector, MS-3102-18-16P					
J303	Connector, HN					UG-496/U
K301	Relay, Mercury Plunger				Durakool	BBT-69
K303	24v Coil Norm. Closed Fast Open, 1 sec Reclose					
K302	Relay, Mercury Wetted Contracts 24v Coil 3 P.D.T.				Clare	HG3A1004
K304	Relay, Mercury Plunger 24v Coil SPST NO				Durakool	BF 2000
S301	Switch, Interlock				Microswitch	13AC-1
DS301	Pilot Light, #327 Lamp	24v			Dial Co.	183-9730-1472
CR301 CR302 CR303 CR304	Silicon Diode				Internation Rect.	5A2
VR301	Zener Diode	1200v	12w		General Electric	A27N
V301	Diode, Regulator					OB2
V302	Diode, Regulator					OB2
R301	Resistor, Composition	75kΩ	2w	5%	Ohmite	
R302	Resistor, Composition	75kΩ	2w	5%	Ohmite	

CHASSIS #300 - CAPACITOR DISCHARGE (CONT)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R303	Resistor, Deposited Carbon	2.43 megΩ	2w	1%		
R304, R305, R306	Resistor, Deposited Carbon	2.37 megΩ	2w	1%		
R307	Resistor, Deposited Carbon	1.18 megΩ	2w	1%		
R308	Resistor, Wirewound	50kΩ	20w	10%		
C301	Capacitor, Special	.001µf	1kv		Plastic Capacitors Inc.	PX10-102E1
C302	Capacitor, Special	.0022µf	1kv		Plastic Capacitors Inc.	PX10-222E1
C303	Capacitor, Special	.004µf	1kv		Plastic Capacitors Inc.	PX10-402E1
C304	Capacitor, Special	.01µf	1kv		Plastic Capacitors Inc.	PX10-103E1
C305	Capacitor, Special	.1µfd	1kv		Plastic Capacitors Inc.	PX10-104
C306	Capacitor, Special	.4µfd	1kv		Plastic Capacitors Inc.	PD10-404E1
C307	Capacitor, Special	.7µfd	1kv		Plastic Capacitors Inc.	PD10-704E1
C308	Capacitor, Special	1.0µfd	1kv		Plastic Capacitors Inc.	PD10-105E1
C309	Capacitor, Special	16µfd	200v		Plastic Capacitors Inc.	AB2-166x1

CHASSIS #400 - EBW

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
J401	Connector, MS3102-24-20P					
J402	Connector, MS3102-18-16P					
J403	Connector, BNC					UG-657/U
J404	Connector, BNC					UG-657/U
J405	Connector, BNC					UG-657/U
T401	Transformer, Filament	2.5v	10 amp		Thordarson	21F02
T402	Transformer, Power	650v	40 ma		Stancor	PC8406
K401	Relay, Mercury Plunger 24 vdc Coil				Durakool	CFC 306
CR401	Silicon Rectifier				International Rectifier	5A2
CR402	Silicon Rectifier 3600 PRV, 65 ma				International Rectifier	1N1139
S401	Interlock Switch				Micro Switch	13AC1
R401	Resistor, Wirewound	75kΩ	20w	10%		
R402	Resistor, Wirewound	75kΩ	20w	10%		
R403	Resistor, Deposited Carbon	1.18 megΩ	2w	1%		
R404	Resistor, Deposited Carbon	2.37 megΩ	2w	1%		
R405	Resistor, Deposited Carbon	2.37 megΩ	2w	1%		

CHASSIS #400 - EBW (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R406	Resistor, Deposited Carbon	2.37 megΩ	2w	1%		
R407	Resistor, Deposited Carbon	2.43 megΩ	2w	1%		
R408	Resistor, Special	.05Ω			FIL	
R409	Resistor, Composition	2.4 kΩ	2w	5%	Ohmite	
R410	Resistor, Composition	2.4 kΩ	2w	5%	Ohmite	
R411	Resistor, Composition	2.4 kΩ	2w	5%	Ohmite	
R412	Resistor, Composition	2.7 kΩ	2w	5%	Ohmite	
R413	Resistor, Composition	1 kΩ	2w	5%	Ohmite	
R414	Resistor, Composition	10 kΩ	2w	5%	Ohmite	
R415	Resistor, Composition	10 kΩ	2w	5%	Ohmite	
R416	Resistor, Composition	10 kΩ	2w	5%	Ohmite	
R417	Resistor, Composition	10 kΩ	2w	5%	Ohmite	
R418	Resistor, Composition	2.7Ω	1w	10%	Ohmite	
R419	Resistor, Composition	4 megΩ	2w	5%	Ohmite	
R420	Resistor, Composition	51 kΩ	2w	5%	Ohmite	
R421	Heater, Ignition	2.5c			FIL	
C401		1μfd	6kv	5%	Sprague	
C402		2μfd	6kv	5%	Electric	
C403		10μfd	6kv	5%	Co.	

CHASSIS #400 - EBW (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
C404	Capacitor, Pyranol	1μfd	3kv		General Electric	23F124
V401	Ignitron				General Electric	GL7171

CHASSIS #500 - DUMMY LOADS

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
S501	Rotary Switch 2 Decks 8 Position 36°				Radio Switch Co.	Model 88
J501	Connector MS3102-24-9P					
R501 to R505	Resistor, Composition	5kΩ	2w	5%	Ohmite	
R506	Resistor, Special	8Ω	17 amps	2%	Post Glover	78-T226-A

CHASSIS #600 - REMOTE RELAY BOX

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
K601	Relay, Mercury Plunger				Durakool	CFFBC 301
K602	2 NO, INC 24v Coil					
CR601 CR602	Diode, Silicon				International Rectifier	5A2
J601	Connector, MS3102-28-6S					
J602	Connector, MS3102-28-6P					
J603	Connector, MS3102-28-9P					
J604	Connector, MS3102-16S6-S					
J605	Connector, HN					UG-496-U

CHASSIS #700 - FLASH DETECTOR

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
PL701	Plug, ACW Ground				Hubbell	5267
J701	Connector, BNC					UG-657/U
SW701	Switch, SPST Toggle					
F701	Fuse, SB3AG	1a	250v			
DS701	Light, Pilot: NE2D Lamp				Dialight	137-8836-931
T701	Transformer, Power				Thordarson	22R31
L701	Inductor, Filter	8H	40ma		U.T.C.	R14
C701	Capacitor,	10µf	1kv			
C702	Oil Filled					
C703	Capacitor, Paper	.01µf	600v			
V701	Photomultiplier					1P21
V702	Diode, Dual					5R4GYA
R701	Resistor, Composition	100kΩ	½w	5%	Ohmite	
R710	Resistor, Composition					
R711	Resistor, Composition	100kΩ	1w	5%	Ohmite	

CHASSIS #800 - POWER CONTROL

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
T801	Transformer, Power	27v	8 amp		Signal	36-8
L801	Inductor, Filter	.03 Henry, .3Ω	8 amp		Signal	CH-8
F801	Fuse, SB 4AG	10 amp	250v			
F802	Fuse, SB 4AG	2 amp	250v			
F803	Fuse, SB 4AG	3 amp	250v			
S801 S802	Switch, Toggle DPST	12 amp			Arrow HEH	596
J801 to J807	Receptacle, AC w/ground				Hubbell	5258
J808	Plug, AC w/ground				Hubbell	5278
J809	Connector, MS3102-16S6-S					
J810	Connector, MS3102-28-20S					
J811	Connector, MS3102-22-5P					
J812	Connector, MS3102-18-16P					
DS801	Light, Pilot: NE2D Lamp				Dialight	137-8836-933
SD802	Light, Pilot: 877 Lamp				Dialight	101-5030-932
J813	Connector, MS3102-18-16S					
R801 R802	Resistor, Wirewound	100kΩ	50w			

CHASSIS #800 - POWER CONTROL (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Numbers
C801	Capacitor, Electrolytic	15,000µfd	40v			
K801	Relay, Mercury Plunger 1NO, INC; 24v Coil				Durakool	CFBC-301
K802	Relay, Mercury Plunger NO: 24v Coil				Durakool	BFC 316
CR801	Rectifier, Silicon Bridge	35v	12a		Siltab	A64
CR802, CR803	Diode, Silicon				International Rectifier	5A2

CHASSIS #900 - SCR/RAMP GENERATOR

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
J901	Connector, MS3102-24-12P					
J902	Connector, MS3102-32-6P					
J903	Connector, MS3102-28-22S					
J904	Connector, BNC					UG-657/U
J905	Connector, MS3102-24-12S					
K901	Relay, Mercury Wetted Contacts 24v Coil				Clare	HG 1004
K902	Relay, Mercury Plunger NC, 24v Coil				Durakool	BBC 303
K903	Relay, SPDT 10kΩ Coil				Potter & Brumfield	SS5D
DS901	Light, Pilot (#927 Lamp)				Dialco	183-9730-1471
VR901	Diode, Zener	33v	10w	20%		1N1825
VR902	Diode, Zener	33v	10w	5%		1N2990B
VR903	Diode, Zener		10w	20%		1N2976
VR904	Diode, Zener		10w	20%		1N2992
VR905						
VR906						
VR907						
VR908						
CR901	Diode, Silicon					1N2156

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
CR902	Diode, Silicon				International Rectifier	5A2
CR903	Diode, Silicon					
CR904	Diode, Silicon				Raytheon	1N536
CR905	Diode, Silicon				Raytheon	1N3728
CR906	Diode, Silicon				Raytheon	1N3728
CR907	Diode, Silicon					1N536
CR908	Diode, Silicon				Raytheon	1N3728
CR909	Diode, Silicon					1N536
CR910	Diode, Silicon				Raytheon	1N3728
CR911	Diode, Silicon					1N536
CR912	Diode, Silicon				Raytheon	1N3728
CR913	Diode, Silicon					1N536
CR914	Diode, Silicon					1N3728
SCR901	Rectifier, Silicon Controlled				International Rectifier	70RE80
SCR902	Rectifier, Silicon Controlled				Westinghouse	WX809H06
L901	Choke, R.F.	10mh				
Q901	Transistor, PNP					2N1395
Q902	Transistor, NPN					2N699

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
Q903	Transistor, NPN					2N1492
Q904	Transistor, PNP Power					2N1906
Q905	Transistor, PNP Power					2N442
Q906	Transistor, PNP Power					2N442
Q907	Transistor, PNP Power					2N442
Q908	Transistor, PNP Power					2N442
Q909	Transistor, PNP Power					2N442
V901	Pentode					6AS6
V902	Triode, Dual					6350
V903	Diode, Dual					6AL5
V904	Triode, Dual					12AU7
V905	Triode, Dual					12AU7
V906	Thyratron					2D21
V907	Thyratron					2D21
C901	Capacitor, Mica	20pf	600v			
C902	Capacitor, Mica	300pf	600v			
C903	Capacitor, Ceramic	.0012µf	1kv			
C904	Capacitor, Paper (.001µf and .008µf in parallel)	.009µf	600v			
C905	Capacitor, Paper	.05µfd	200v			

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
C906	Capacitor, Mylar	.33µfd	200v			
C907	Capacitor (Mylar 1.5µf and paper 0 1µf in parallel)	1.6	200v			
C908	Capacitor, Mylar	10µf	200v			
C909	Capacitor, Telephone Electrolytic	50µf	250v		Sagaino	TR-2550
C910	Capacitor, Mica	30pf	600v			
C911	Capacitor, Mylar	.5µf	200v			
C912	Capacitor, Ceramic	120pf	1kv			
C913	Capacitor, Paper	.01µf	600v			
C914	Capacitor, Ceramic	200µf	1kv			
C915	Capacitor, Ceramic	200µf	1kv			
C916	Capacitor, Mylar	.22µf	400v			
C917	Capacitor, Oil Filled	20µf	300v			
C918	Capacitor, Mylar	.22µfd	400v			
C919	Capacitor, Mylar	.22µfd	400v			
C920, C921	Capacitor, Electrolytic	500µfd	50v			
C922	Capacitor, Mylar	.1µf	200v			
R901	Resistor, Composition	30kΩ	½w	5%	Ohmite	

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R902	Resistor, Composition	1 megΩ	$\frac{1}{2}$w	5%	Ohmite	
R903	Resistor, Composition	750kΩ	$\frac{1}{2}$w	5%	Ohmite	
R904	Resistor, Composition	150kΩ	1w	5%	Ohmite	
R905	Resistor Composition	75kΩ	2w	5%	Ohmite	
R906	Resistor, 10 Turn Variable	250kΩ	2.5w	3%	Bourns	3640S-1-254
R907	Resistor, Composition	6.2kΩ	$\frac{1}{2}$w	5%	Ohmite	
R908	Resistor, Composition	390kΩ	$\frac{1}{2}$w	5%	Ohmite	
R909	Resistor, Composition	680Ω	1w	10%	IRC	
R910	Resistor, Wirewound	20kΩ	10w	10%		
R911	Resistor, Variable	500Ω	$\frac{1}{4}$w	10%	Bourns	273-1-501M
R912	Resistor, Wirewound	20kΩ	10w	10%		
R913	Resistor, Composition	3kΩ	$\frac{1}{2}$w	5%	Ohmite	
R914	Resistor, Composition	68kΩ	2w	5%	Ohmite	
R915	Resistor, Composition	1.2kΩ	$\frac{1}{2}$w	5%	Ohmite	
R916	Resistor, Composition	30kΩ	2w	5%	Ohmite	
R917	Resistor, Composition	24kΩ	1w	5%	Ohmite	
R918	Resistor, Composition	24kΩ	$\frac{1}{2}$w	5%	Ohmite	
R919	Resistor, Composition	2.2kΩ	$\frac{1}{2}$w	5%	Ohmite	
R920	Resistor, Composition	1 megΩ	$\frac{1}{2}$w	5%	Ohmite	

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R921	Resistor, Composition	2.2kΩ	½w	5%	Ohmite	
R922	Resistor, Composition	24kΩ	½w	5%	Ohmite	
R923	Resistor, Composition	51kΩ	½w	5%	Ohmite	
R924	Resistor, Composition	180kΩ	½w	5%	Ohmite	
R925	Resistor, Composition	120kΩ	½w	5%	Ohmite	
R926	Resistor, Composition	2.7Ω	1w	10%	Ohmite	
R927	Resistor, Composition	5.1kΩ	2w	5%	Ohmite	
R928	Resistor, Composition	1 megΩ	½w	5%	Ohmite	
R929	Resistor, Composition	1 megΩ	½w	5%	Ohmite	
R930	Resistor, Composition	24kΩ	2w	5%	Ohmite	
R931	Resistor, Composition	820kΩ	2w	5%	Ohmite	
R932	Resistor, Composition	51Ω	2w	5%	Ohmite	
R933	Resistor, Composition	820kΩ	2w	5%	Ohmite	
R934	Resistor, Composition	51Ω	2w	5%	Ohmite	
R935	Resistor, Composition	15kΩ	2w	10%	Ohmite	
R936	Resistor, Composition	820Ω	1w	5%	Ohmite	
R937	Resistor, 10 Turn Variable	10kΩ	2w	3%	Bourns	3500S-1-103
R938	Resistor, Composition	510k	½w	5%	Ohmite	
R939	Resistor, Composition	1.5kΩ	½w	5%	Ohmite	

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R940	Resistor, 10 Turn Variable	5kΩ	2w	3%	Bourns	3500S-1-502
R941	Resistor, Composition	2.2kΩ	½w	5%	Ohmite	
R942	Resistor, Composition	3.3kΩ	½w	5%	Ohmite	
R943	Resistor, Wirewound	100Ω	20w	10%		
R944	Resistor, Wirewound	45Ω	25w	10%	Workman	25w
R945	Resistor, Composition	150Ω	1w	5%	Ohmite	
R946	Resistor, Composition	1kΩ	½w	5%	Ohmite	
R947	Resistor, Composition	100Ω	½w	5%	Ohmite	
R948	Resistor, Composition	100Ω	2w	5%	Ohmite	
R949	Resistor, Composition	200Ω	½w	5%	Ohmite	
R950	Resistor, Wirewound, 2-5Ω in par.	2.5Ω	100w	10%		
R951	Resistor, Composition	200Ω	½w	5%	Ohmite	
R952	Resistor, Wirewound (2.5Ω in par.)	2.5Ω	100w	10%		
R953	Resistor, Composition	200Ω	½w	5%	Ohmite	
R954	Resistor, Wirewound (2-5Ω in par.)	2.5Ω	100w	10%		
R955	Resistor, Composition	200Ω	½w	5%	Ohmite	
R956	Resistor, Wirewound (2-5Ω in par.)	2.5Ω	100w	10%		
R957	Resistor, Composition	200Ω	½w	5%	Ohmite	

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
R958	Resistor, Wirewound (2-5Ω in par.)	2.5Ω	100w	10%		
R959	Resistor, Composition	5.1k	2w	5%		
R960	Resistor, Wirewound (4-5Ω 120w in parallel)	1.25Ω	500w	10%		
R961	Resistor, Composition	2.4kΩ	1w	5%	Ohmite	
R962	Resistor, Wirewound	50Ω	50w	10%		
R963	Resistor, Composition	2.4kΩ	1w	5%	Ohmite	
R964	Resistor, Wirewound	50Ω	50w	10%		
R965	Resistor, Composition	2.4kΩ	1w	5%	Ohmite	
R966	Resistor, Wirewound	50Ω	50w	10%		
R967	Resistor, Composition	2.4kΩ	1w	5%	Ohmite	
R968	Resistor, Wirewound	50Ω	50w	10%		
R969	Resistor, Wirewound	50Ω	50w	10%		
R970	Resistor, Composition	2.4kΩ	1w	5%	Ohmite	
S901	Switch, Rotary 3 Decks, 2 Pos. R Rotor 30°				Radio Switch Co.	Model 85
S902	Switch, Toggle DPDT - both sections in Parallel		15 amp			
S903	Switch, Rotary 1 Pole, 7 Pos.				Mallory	31117-J

CHASSIS #900 - SCR/RAMP GENERATOR (CONT.)

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
B901	Fan, Muffin				Rotron	Venturi
	Heat Sink, 6 Module Air Cooled				IERC	F600

CHASSIS #1000 (MOUNTED IN RACK) SCR MODE SELECTOR

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
S1001	Rotary Switch 4 Deck, 9 Pos. 36° Rotor				Radio Switch Corporation	Model 88
PL1001	Connector MS3106-28-22P					
PL1002	Connector MS3106-24-12P					
R1001	Resistor, Special	1Ω	60 amps	1%	Post-Glover	40-T214-A
R1002	Resistor, Non Inductive	160Ω	250w	1%	Dale	NH-250
R1003	Resistor, 2-125Ω Resistors in parallel	125Ω	250w	1%	Dale	NH-250
R1004	Resistor, 4-125Ω Resistors in parallel	125Ω	250w	1%	Dale	NH-250
R1005	Resistor, Special	15Ω	16 amp	2%	Post-Glover	102-T-228-A
R1006	Resistor, Special	1Ω	60 amp	2%	Post-Glover	40-T214-A

ADDITION TO NJE MODEL RA 16050 - CM POWER SUPPLY CHASSIS #1100

Symbol	Description	Value	Rating	Tol.	Mfg.	Mfg. Number
T1101	Variable Transformer					Superior 10B-3
T1102 T1103 T1104	Filament Transformer					Stancor P6468

APPENDIX D

INSTALLATION INSTRUCTIONS

SEE REVERSE SIDE FOR FILTER FAN INSTALLATION

GOLD SEAL *muffin*® *fan*®

ROTRON®

OPERATE ON 115 VAC, 60 CPS, 1 PHASE ONLY

$5\frac{11}{32}'' \pm \frac{1}{64}''$

$\frac{3}{16}'' \pm \frac{1}{32}''$ — $\frac{1}{8}''$ Maximum Radius — $\frac{3}{16}'' \pm \frac{1}{32}''$

$\frac{3}{4}''$ — $3\frac{1}{2}'' \pm \frac{1}{64}''$ — $5'' \pm \frac{1}{32}''$

CUT ALONG THIS LINE

CUT ALONG THIS LINE

INSTALLATION INSTRUCTIONS
GRILLE FAN

1. Drill or punch four .144" dia. holes. Use this drawing as a template if desired, or note dimensions.

2. Cut rectangular opening in panel.

3. Attach spring steel Mounting Clips with #6 flat head screws of type and length to suit panel.

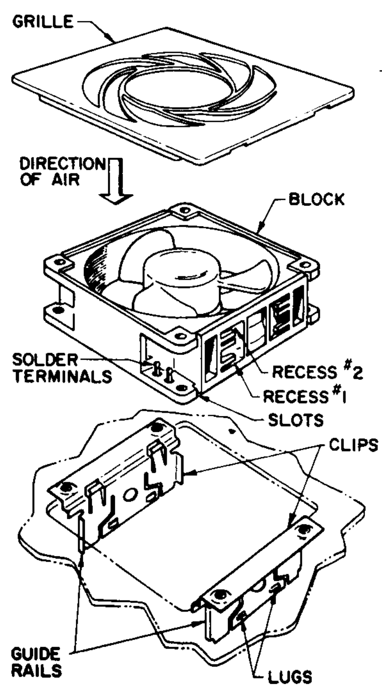
4. Insert block between clips so that the formed guide rails on the clips enter the slots in the block. For air movement in the direction shown, push the block in until the lugs in the clips snap into the four recesses in the block, shown as recess #1. Block is now locked in place.

5. The Grille is pressed down between clips as far as it will go. It is held in place by retaining fingers on the clips.

IF BLOCK MUST BE REMOVED, spring tabs carrying lugs can be pried away from block with a knife or screw driver inserted along inside edge of clip. Block should then be drawn out, not pushed in.

FOR AIR MOVEMENT IN OPPOSITE DIRECTION, block should be turned over and inserted so that lugs enter recesses on opposite side, shown as recess #2.

LEADS should be soldered to terminals.



See other side for installation of FILTER FAN.

$.144^{+.005}_{-.001}$ Dia. (4) Holes
(#27 Drill)

ROTRON®

ROTRON MANUFACTURING COMPANY, INC.
Hasbrouck Lane Woodstock, New York

FILTER FAN INSTALLATION

1. Drill or punch four .144" dia. holes. Use drawing on front of this sheet as a template if desired, or note dimensions.

2. Cut rectangular opening in panel as shown on front of this sheet.

3. Attach spring steel Mounting Clips with #6 flat head screws of type and length to suit panel.

4. Insert block between clips so that the formed guide rails on the clips enter the slots in the block. For air movement in the direction shown, slide the block in until the lugs in the clips snap into the recesses in the block, shown as recess #3. It is necessary to bend the clips slightly away from the block while inserting it so that recess #1 and the outer wall of recess #3 will not engage the clips prematurely.

5. Insert Filter box and frame assembly between the clips. It is held in place by retaining fingers on the clips.

If block must be removed, spring tabs carrying lugs can be pried away from block with a knife or screw driver inserted along inside edge of clip. Block should then be drawn out, not pushed in.

Leads should be soldered to the terminals.

OILING THE MUFFIN FAN TO EXTEND LIFE UNDER EXTREME ENVIRONMENTAL CONDITIONS

The new GOLD SEAL MUFFIN FAN with the latest electrical and mechanical advances in the motor design, offers reliable performance from 2 to 5 years under favorable conditions of temperature and vibration without the necessity of oiling. Its life is in inverse proportion to these factors. For example, at 110°F the fan may be expected to give reliable performance in excess of three years and at 40°F, reliable performance is extended beyond five years.

If the fan should be installed in areas of greater heat, or severe vibration, its life may be extended by periodic oilings (a small amount once per year) which is absorbed by the bearing. For this oiling procedure, an OIL INJECTOR is required, which may be ordered from Rotron at a modest price of $1.50 each. This OIL INJECTOR, will service from 15 to 20 GOLD SEAL MUFFIN FANS. For refills order Muffin Fan Lubricant in 4 oz. can.

Procedure:

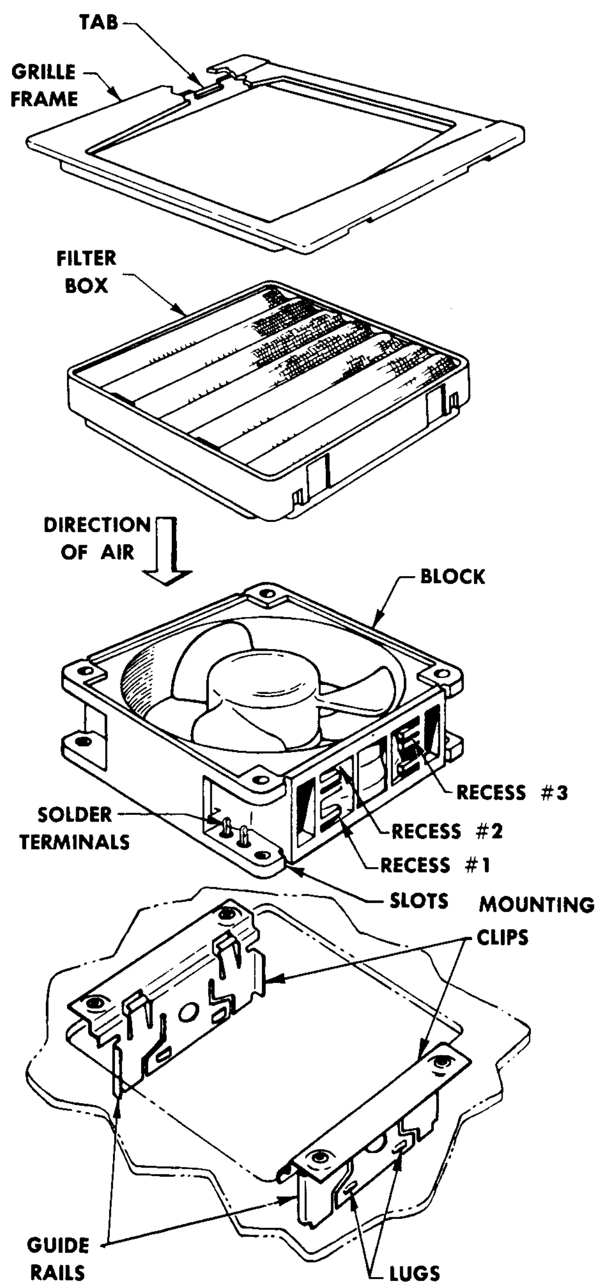
1. Remove cap from end of OIL INJECTOR.
2. Place needle at the center of circle marked on the Gold label.
3. Position the needle at an angle of approximately 45° to the surface of the label and tangent to the perimeter of the circle.
4. Pierce the label and the concealed self-sealing rubber cap located under the label.
5. Insert the needle approximately ¼".
6. Depress the plunger of the OIL INJECTOR slowly to the next calibration mark which will allow 1/16" of oil to escape.

Note:

It is better to give a little more oil than not enough, however, do not overflow the well.

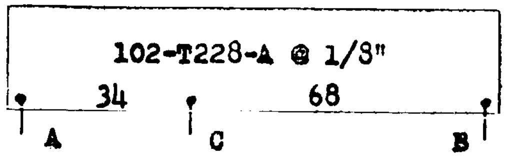
If the ambient temperatures are extremely hot, it may be advisable to oil more frequently to insure the optimum performance characteristics of the fan.

SEE REVERSE SIDE FOR INSTALLATION OF GRILLE FAN



NOTE:
1. Mounting Clips are supplied only with the Grilled Fan and Filter Fan.
2. Screws are not supplied.

UNIT "A"

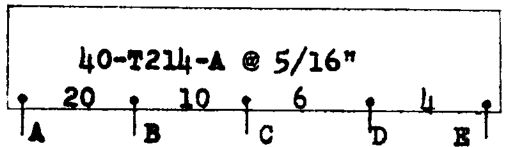


STEP	RES.	C. C.	R/G
A-B	15.0	16	.147
A-C	5.0	16	.147

Dimensions: 19" long
11" wide (over terminals)
6" high

Frame #2041-6"
Terminals #0681

UNIT "B"

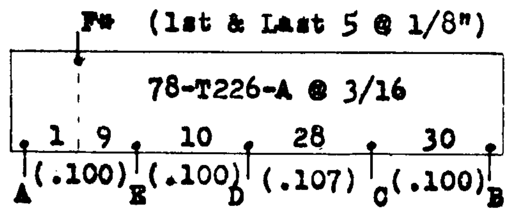


STEP	RES.	C.C.	R/G
D-E	.10	60	.025
C-E	.25	60	.025
B-E	.50	60	.025
A-E	1.00	60	.025

Dimensions: 20" long
12" wide (Over Terminals)
6" high

Frame #2041-6"
Terminals #0691

UNIT "C"

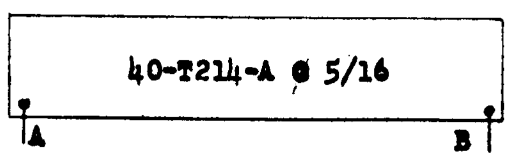


STEP	RES.	C.C.
A-F	.10	17
A-E	1.00	17
A-D	2.00	17
A-C	5.00	17
A-B	8.00	17

Dimensions: 20" long
11" wide (over terminals)
6" high

Frame #2041-6"
Terminals #0681 * - "C" Pos.

UNIT "D"



STEP	RES.	C.C.	R/G
A-B	1.00	60	.025

Dimensions: 20" long
12" wide, (over terminals)
6" high

Frame #2041-6"
Terminals #0691

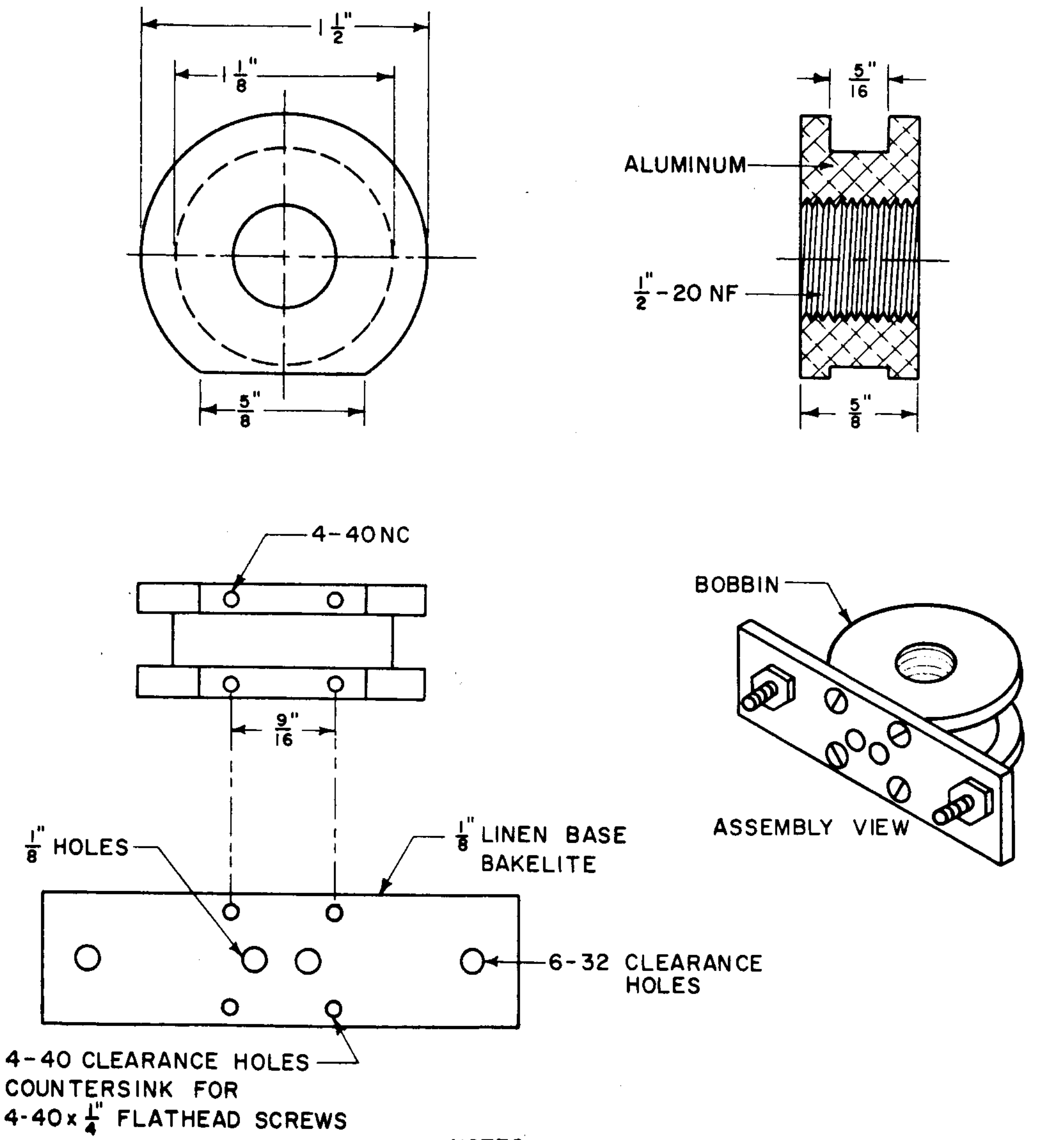
Units "A", "B" & "C" resistance tolerance ± 2%
Unit "D" resistance tolerance ± 1%

THE POST-GLOVER ELECTRIC CO.
ERLANGER, KENTUCKY

CUSTOMER'S ORDER NO.

THE FRANKLIN INSTITUTE
PHILADELPHIA, PA.

CHH	1/24/64	NONE	17521



NOTES:

WIND BOBBIN WITH NICHROME WIRE
(1.7 ohm/ft) x 2.3 FEET LONG.

INSULATE WIRE WITH "HEAT PROOF" SPAGHETTI

NOT DRAWN TO SCALE.

Heater for GL-7171 Ignitron Anode